POWER

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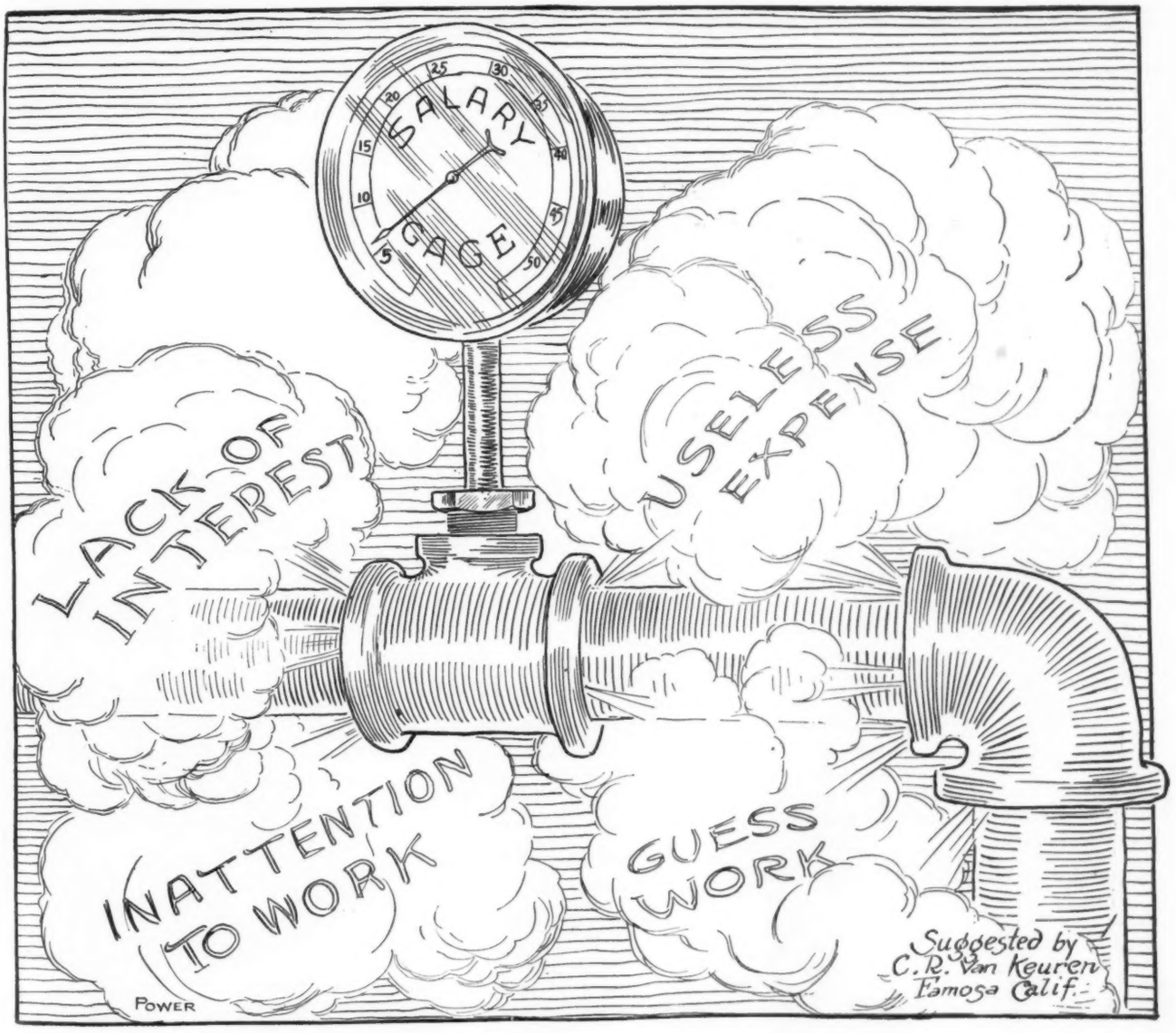
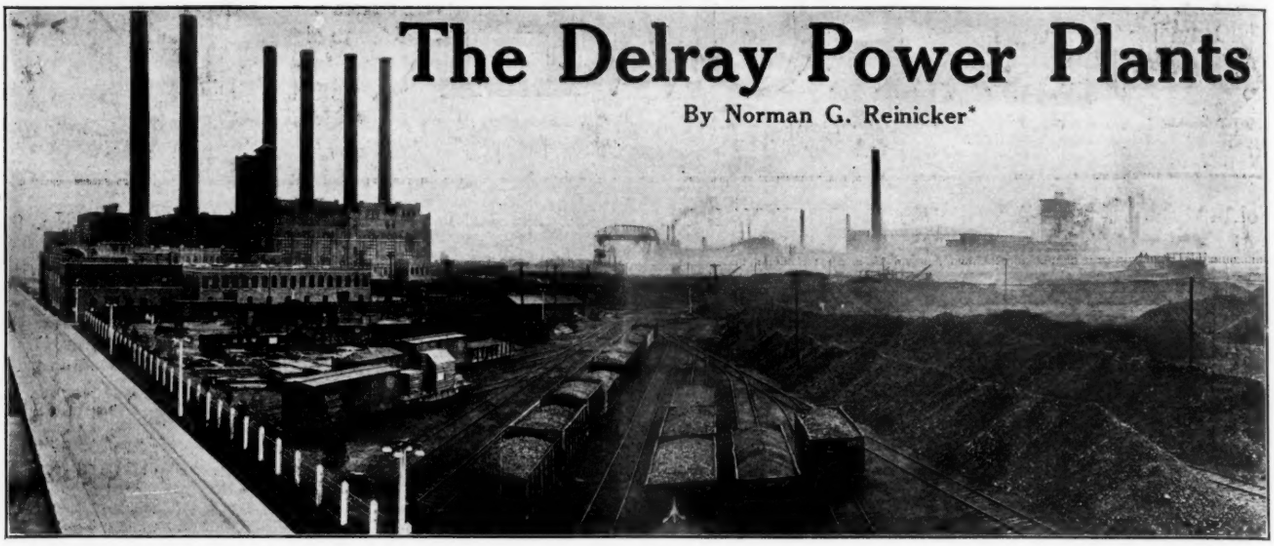
Losing Pressure



Stop These Leaks and Watch the Hand Move



The Delray Power Plants

By Norman G. Reinicker*

SYNOPSIS—This article is the first of a series telling of the operation of the Delray power houses of the Edison Illuminating Co. of Detroit, Mich. The general layout of the property and of the plants is covered briefly, relying on the list of principal apparatus to answer questions regarding the details of the equipment. Later articles will tell of the methods used, the schemes followed and the results obtained.

The Delray power houses, the main generating stations of the Edison Illuminating Co. of Detroit, are situated on the Detroit River about four miles west of the city and adjacent to the United States army post, Fort Wayne. A general layout of the property is shown in Fig. 1. The plant was located here because the property was at the terminus of a short railroad connecting with two of the important railroads entering Detroit and because of the abundant supply of condensing water available.

Three-phase, 60-cycle currents are generated at 4800 volts. All of the current is transmitted under ground, part at the generated voltage and part at 24,000 volts, to the various substations in and around Detroit. The company does a general commercial light and power business, supplies power for manufacturing purposes to a number of large consumers and furnishes part of the power used by the street-railway company in operating its interurban lines. The city has its own plant for street and municipal-building lighting, and the street-car company operates two large plants for its city service.

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Power House No. 1

The original plant, built in 1904, was designed for four 3000-kw. (maximum rating) vertical Curtis turbines running condensing, each being supplied with steam by a

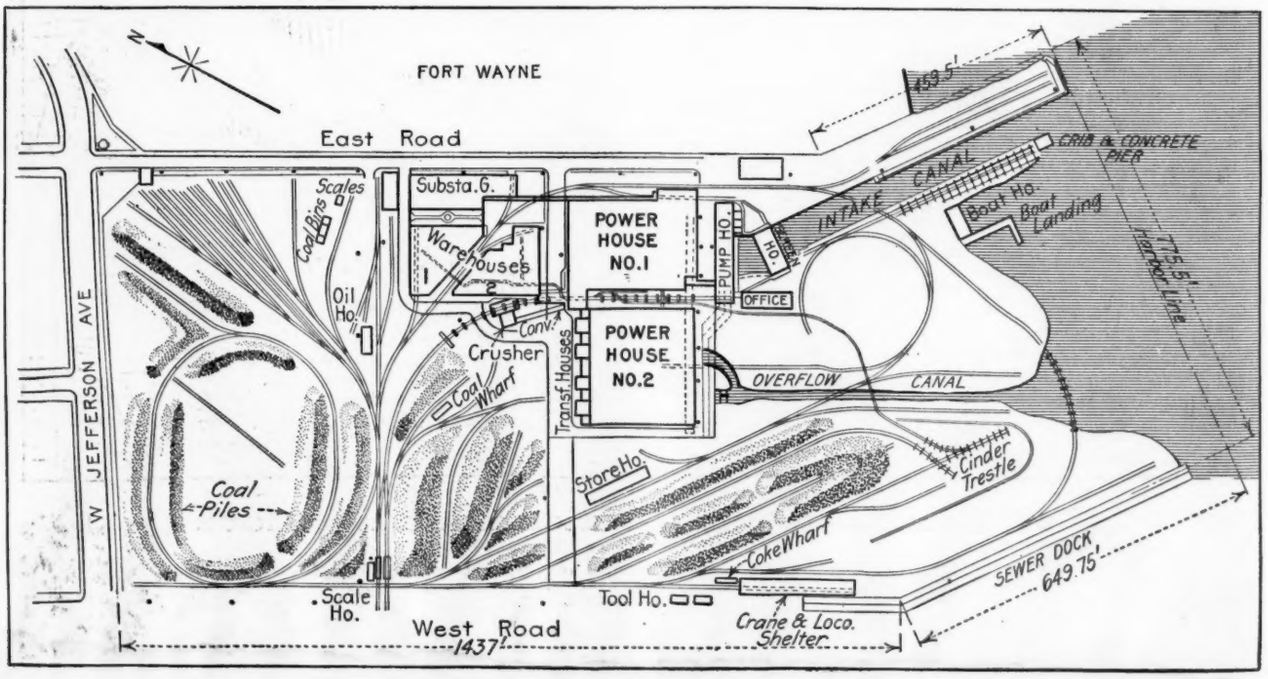


FIG. 1. GENERAL LAYOUT OF THE DELRAY PROPERTY

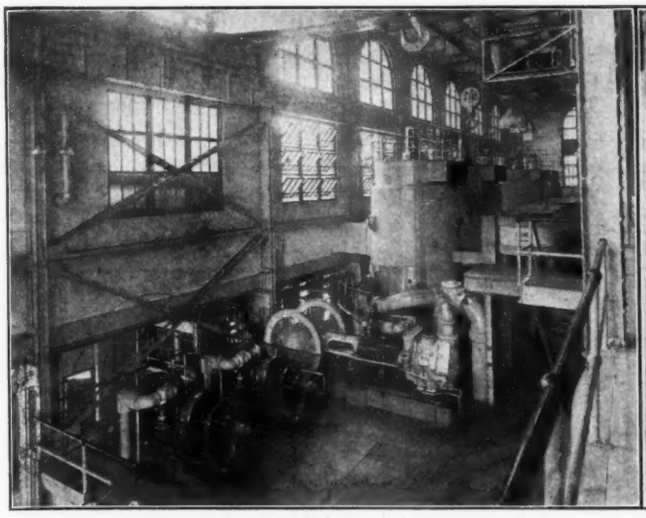


FIG. 2. TURBINE ROOM OF POWER HOUSE NO. 1

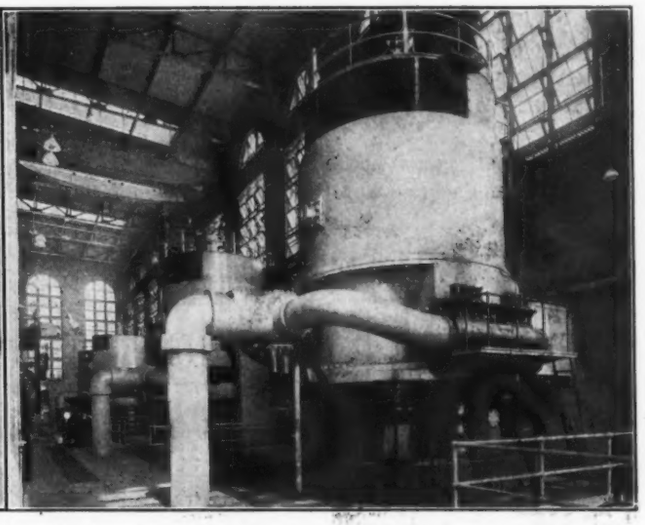


FIG. 3. TURBINE ROOM OF POWER HOUSE NO. 2

battery of six Stirling boilers equipped with economizers and Roney stokers. In 1907 a fifth turbine of 3000-kw. capacity was installed, taking the excess steam from the 24 boilers.

This plant was rebuilt in 1911, the four 3000-kw. turbines being replaced by four 8000-kw. vertical turbines (8000 kw. normal, 10,000 kw. maximum rating), these machines taking up the same space as their predecessors. The fifth 3000-kw. machine was taken out at this time and was not used again. In the boiler room the Roney stokers were replaced by Taylor stokers and the economizers reset.

The original plant had induced draft and three 150-ft. stacks. Each of the two outside batteries had a stack of its own, while the center batteries were served by a common stack. At the time the stokers were changed these stacks and the induced-draft apparatus were taken down and replaced by two 265-ft. natural-draft stacks, each providing draft for two batteries of boilers. Fig. 4 is the firing aisle of No. 1 boiler room.

Power house No. 1, Fig. 2, now has a maximum capacity of 40,000 kw., whereas the plant as originally designed had a capacity of but 12,000 kw.

Power House No. 2

This is the newer plant, the first section of which was started in 1909. The plant was designed for four 14,000-kw. (maximum rating) vertical turbines, Fig. 3, three of which are installed, the fourth having a rated capacity of 15,000 kw. (18,000 kw. maximum). The boiler room, Fig. 5, was designed for twelve special type "W" Stirling boilers of 2365-hp. rating, nine of which are now installed.

The intention was to use three of these in a battery on a common stack to supply steam to one turbine, and the first battery is so arranged. The amount of steam obtained from these large boilers far exceeded the original expectations, so that only two of them are installed in the other batteries. Even with this arrangement the 14,000-kw. turbine cannot use the steam generated by the two boilers. Much has been written, and there has been much discussion, on these boilers since Doctor Jacobus' report of the test in the A. S. M. E. "Proceedings," of November, 1912. Details of the large boilers and the earlier experiences in connection with their operation are covered in J. W. Parker's paper on "Notes on the Further Operation of Large Boilers," in the A. S. M. E. "Proceedings," of December, 1913. The only other apparatus about the plant not in accordance with general power-plant practice are the exceptionally large boiler-feed pumps having a rated capacity of 1600 gal. per min. There are four

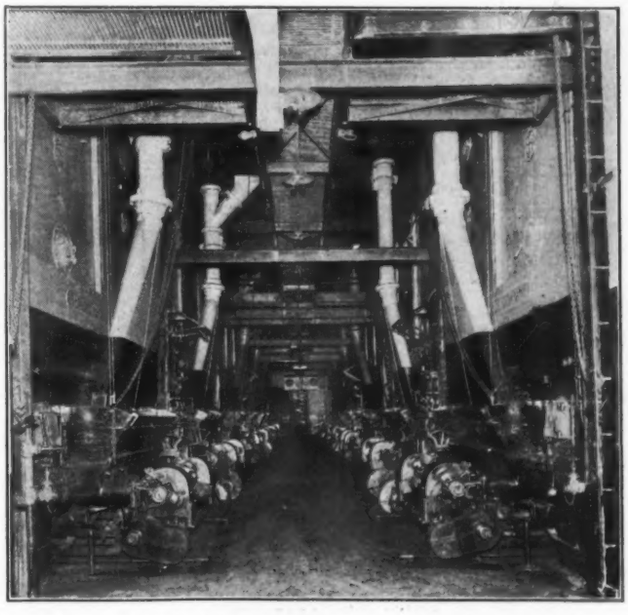


FIG. 4. FIRING AISLE OF NO. 1 BOILER ROOM

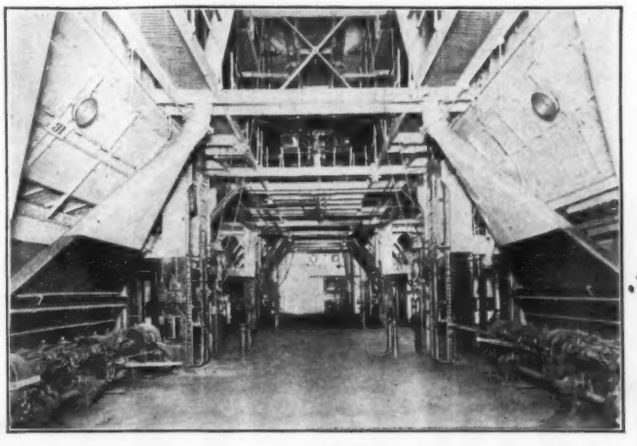


FIG. 5. THE BOILER ROOM FOR PLANT NO. 2

of these pumps installed, three steam-driven and one electric. Two of them are capable of taking care of the entire load on the plant at any time of the day. Fig. 6 is a general plan of the power houses, showing the steam piping.

The original screen house was designed for pairs of vertical screens which were lifted out by a crane and screens. Both the old and new screen houses were described in the Mar. 9, 1915, issue of *Power* by Prof. C. F. Hirshfeld.

The station busbars are carried to this substation on an overhead bridge. Here some of the current is stepped up to 24,000 volts, and part of the current is used in 500-kw. and 1000-kw. motor-generator sets for supply-

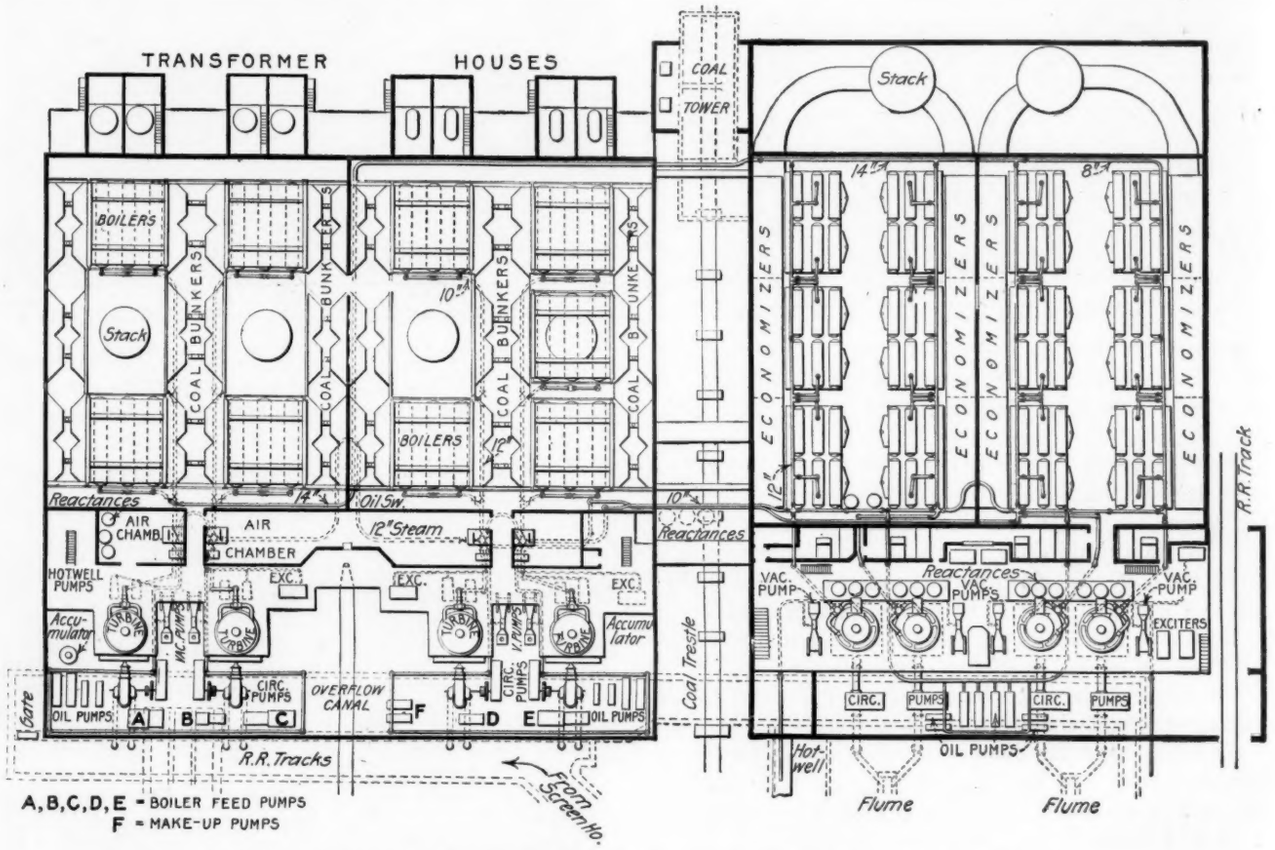


FIG. 6. GENERAL PLAN OF POWER HOUSES, SHOWING STEAM PIPING

washed with a hose. This building also contained the circulating-water pumps for the original 3000-kw. units. In 1910 a second floor was added for use as offices and drafting rooms. The building now contains the fire pumps, air compressor, surge pumps and water-treating apparatus. During 1914 a new screen house was built over the intake canal to house self-cleaning, traveling

ing 550-volt direct current to the street railway. At the north end of the boiler room of power house No. 2 there are four 6000-kw. and four 7500-kw. transformers, which also step up the current to 24,000 volts. Most of the output of the plant now goes through these transformers, the rest being taken off the station bus at 4800 volts directly to substations.

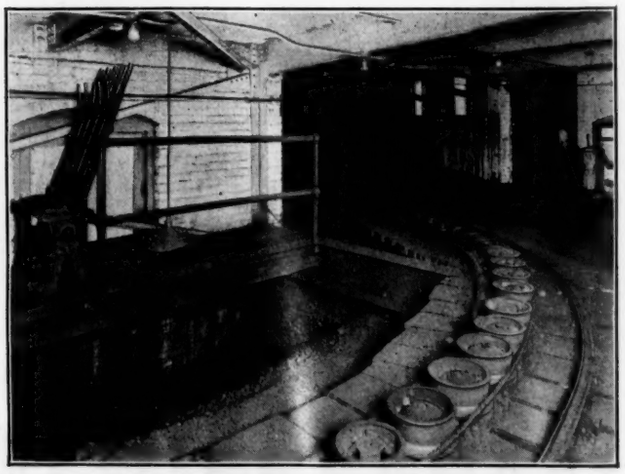


FIG. 7. CABLE TRACKS OVER THE BUNKERS

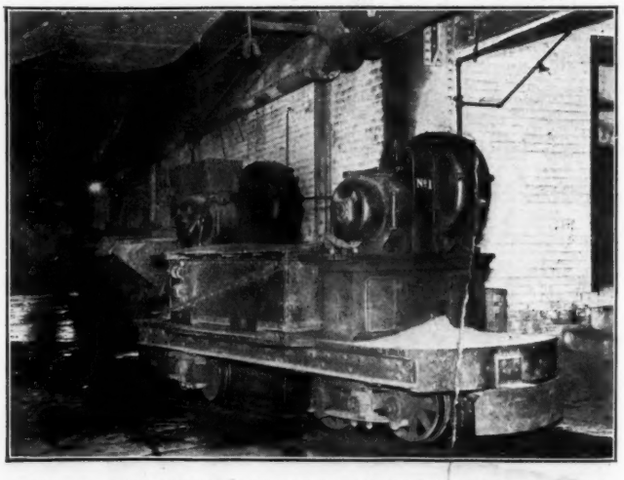


FIG. 8. TWO-TON STORAGE-BATTERY LOCOMOTIVE

The lower floors of the two triangular-shaped buildings shown in Fig. 1 are used as warehouses for storing spare parts and miscellaneous equipment not in use; the rest of the buildings is used for locker, lunch and club rooms. In warehouse building No. 2 there is an auditorium where meetings of company clubs are held. A machine shop for the general repair of locomotive cranes, etc., is shown at the north end of Delray substation. The scale house and timekeeper's office are the only other permanent buildings on the grounds.

The coal-handling system in use is the same as was designed for the original plant. The coal is dumped into hoppers under railway tracks at the base of a coal tower at one corner of the plant. From these hoppers it is carried to the top of the tower by two 2-ton electrically operated skip hoists and dumped into a two-roll crusher. This crusher delivers its coal into hoppers, from which it is taken by cable cars and distributed over the bunkers. While this tower was designed for the original plant only, it is now taking care of both plants, handling as much as 1000 tons of mine-run coal per day of nine hours.

For use as a spare, two single-roll crushers are installed in a building near the coal tower. These crushers receive their coal from pan conveyors which take the coal that has been dumped into a track hopper. After crushing, the coal is carried by a belt conveyor to the skip hoists in the tower and then distributed to the bunkers, as shown in Fig. 7. The method of guiding the cable around a curve is also shown.

The original power house was designed to use narrow-gage dump cars running directly under the ash hoppers. These cars were made up into short trains and pulled out to the ash dump by a mule. The same system was extended into the new plant, the mule being replaced by storage-battery locomotives. The cars are made up into trains of about ten cars each by half-ton locomotives, and then hauled to the dump by a two-ton locomotive such as is shown in Fig. 8.

PRINCIPAL EQUIPMENT OF DELRAY POWER HOUSES

BOILER ROOM—POWER HOUSE NO. 1

No.	Equipment	Kind	Size	Operating Conditions	Maker
24	Boilers	Stirling water-tube	483.4 hp.	200 lb. press., 150 deg. superheat	Babcock & Wilcox Co.
24	Stokers	Taylor underfeed	5 retort	Intermittent dumping	American Engineering Co.
24	Stoker motors	D.-c. shunt-wound	3½hp., 115 volts, 30½ amp.	16 speeds	General Electric Co.
12	Blowers	No. 5 Sirocco	20,000 cu.ft. per min.	Constant-speed, motor-driven	American Blower Co.
12	Blowers	60-in. conoidal	15,000 cu.ft. per min.	Constant-speed, motor-driven	Buffalo Forge Co.
12	Blower motors	Induction	50-hp., 220 volts, 124 amp.	Directly connected to 2 blowers	General Electric Co.
12	Economizers	Cast-iron tube	4896 sq.ft. 32 sections of 12 tubes, 9 ft. x 4½ in. o.d.	One economizer for 2 boilers	Green Engineering Co.
2	Heaters	Reilly multi-coil closed	120,000 lb. per hr. 80-200 deg. F.	Press. steam 50 lb., water 265 lb.	Griscom Russell Co.
2	Stacks	Self-supporting steel	Diam., 17 ft. 9¾ in. top, 24 ft. bottom, 265 ft. high	12 boilers on each stack	Babcock & Wilcox Co.

ENGINE ROOM—POWER HOUSE NO. 1

4	Generators	Type atb., 10 pole	8890 k.v.-a., 4800 volts	60-cycle, three-phase, 720 r.p.m.	General Electric Co.
4	Turbines	Curtis-vertical	5-stage	200 lb. press., 150 deg. sup., 1-in. hg.b.p.	General Electric Co.
4	Condensers	Surface	16,000 sq.ft., 120,000 lb. per hr.	Two pass	H. R. Worthington
1	Dry-vacuum pump	2-stage rotative	12x20x18-in.	200 lb. pressure, 150 deg. superheat, ¾-in. hg.	Laidlaw-Dunn-Gordon
3	Dry-vacuum "	Single-stage	12x27x18-in.	200 lb. press., 150 deg. superheat, ¾-in. hg.	Laidlaw-Dunn-Gordon
6	Wet-vacuum "	2-stage centrifugal	300 g.p.m.	Constant-speed, motor-driven	H. R. Worthington
6	W.V.P. motors	Induction	15 hp., 220 volts, 41 amp.	Directly connected	General Electric Co.
4	Circulating pumps	Tri-rotor centrifugal	24-in., 17,000 g.p.m.	Constant-speed, motor-driven	H. R. Worthington
4	Circulating pump motors	Induction	150 hp., 220 volts, 365 amp.	Constant-speed	General Electric Co.
2	Combination B.F. & W.V.P.	4-stage centrifugal	170,000 lb. per hr.	300 lb. pressure discharge	Westinghouse Machine Co.
2	Combination pump motor	Armature-wound induction	150 hp., 230 volts, 175 amp.	Variable-speed	Westinghouse Elec. & Mfg Co
4	Lubricating-oil pumps	Duplex plunger	7½x4½x10-in.	200 lb. pressure, 150 deg. superheat	H. R. Worthington
4	Step-bearing oil pumps	Duplex plunger	12x3¾x18-in.	200 lb. pressure, 2000 lb. oil pressure	H. R. Worthington
4	Oil filters		Storage 650 gal. capacity 35 g.p.m.	Water-cooled	Turner Oil Filter Co.
2	Accumulators		12-in. diam., 12-ft. stroke weights 6 ft. diam.	1200 lb. pressure, vacuum to 2 turbines	R. D. Wood Co.
2	Exciters	Type CO-4-pole d.c.	125 kw., 125 volts, 1000 amp.	2400 r.p.m.	General Electric Co.
2	Exciter turbines	Curtis horizontal		200 lb. press., 150 deg. sup., non-condensing	General Electric Co.
1	House-service gen.	Type c.c. 4-pole d.c.	125 kw., 125 volts, 1000 amp.	2400 r.p.m.	General Electric Co.
1	House-service turbine	Curtis horizontal		200 lb. press., 150 deg. sup. non condensing	General Electric Co.
2	Motor generators	Induction motor	400 amp., 125/200 v., 720 r.p.m.	Supplies d.c. house service	General Electric Co.

SCREEN HOUSE

12	Screens	Stationary	2½-in. mesh No. 10 B. & S. gage	6 sets, 2 screens per set	Russel Wheel & Foundry Co.
7	Screens	Revolving	No. 12 copper wire; 3-mesh.	Motor-driven	Chain Belt Co.
7	Revolving-screen motor	Induction	5 hp., 220 volts, 148 amp.		General Electric Co.
2	General-service pumps	Horizontal duplex	14 and 20 x 12 x 16-in.		Epping-Carpenter Co.
1	General-service pump	Single-stage centrifugal	8-in.	Constant-speed	H. R. Worthington
1	G.S. pump motor	Induction	60 hp., 220 volts, 15 amp.	Directly connected	General Electric Co.
3	Surge pumps	Horizontal duplex	12x12x16-in.		Epping-Carpenter Co.
1	Air compressor	Horizontal, 2-stage	11/18x19/12x18-in.	Air pressure, 100 lb. steam press., 200 lb., 150 deg. superheat	Laidlaw-Dunn-Gordon
1	Air compressor	Horizontal-sin.-stage	8x8-in.	Motor-driven	Ingersoll-Rand Co.
1	Air-compressor motor	Induction	25 hp., 220 volts, 67 amp.	Belt-connected	General Electric Co.
1	Recirculating pump	Centrifugal	10,000 gal. per min.	Motor-driven	Wheeler Condenser & Engineering Co.
1	Recir.-pump motor	Induction	76 hp., 220 volts, 185 amp.	Directly connected	General Electric Co.

BOILER ROOM, POWER HOUSE NO. 2

9	Boilers	Stirling-water-tube	2365.4 hp.	200 lb. pressure, 150 deg. superheat	Babcock & Wilcox Co.
8	Stokers	Taylor underfeed	2-13 retort, each side	4 with clinker grinders	American Engineering Co.
1	Stoker	Westinghouse underfeed	2-13 retort, each side	Intermittent dumping	Westinghouse Machine Co.
18	Stoker motors	D.c. shunt-wound	7½ hp. 115 volts, 60 amp.	16 Speeds	General Electric Co.
24	Blowers	No. 4½ sirocco	55,000 cu.ft. per min., per unit of 2	Turbine-driven	American Blower Co.
3	Blower turbines	Kerr	175 hp.	200 lb. pressure, 150 deg. superheat	Kerr Steam Turbine Co.
3	Blower turbines	Kerr economy	175 hp.	200 lb. pressure, 150 deg. superheat	Kerr Steam Turbine Co.
6	Blower turbines	Curtis	205 hp.	200 lb. pressure, 150 deg. superheat	General Electric Co.
4	Stacks	Self-supporting steel	Diam. 14 ft. 10½ in. top, 17 ft. bottom, 185 ft. high	2 and 3 boilers on each stack	

PRINCIPAL EPUIPMENT OF DELRAY POWER HOUSES—Continued

ENGINE ROOM, POWER HOUSE NO. 2

No.	Equipment	Kind	Size	Operating Conditions	Maker
3	Generators	Type A.T.B., 10-pole	14,000 kw., 4800 volts	60-cycle, three-phase, 720 r.p.m.	General Electric Co.
1	Generator	Type A.T.B. 10-pole	18750 k.v -a., 4800 volts	60-cycle, three-phase, 720 r.p.m.	General Electric Co.
3	Turbines	Curtis vertical	5-stage	200 lb. pressure, 150 deg. superheat, 1½ in. H.G. back pressure	General Electric Co.
1	Turbine	Curtis vertical	7-stage	200 lb. pressure, 150 deg. superheat, 1½-in. H.G. back pressure	General Electric Co.
3	Condensers	Worthington surface	25,000 sq.ft., 210,000 lb. per hr.	Two pass	H. R. Worthington
1	Condenser	Worthington surface	22,500 sq.ft., 210,000 lb. per hr.	Two pass	H. R. Worthington
3	Dry-vacuum pumps	2-stage rotative	12x31x24-in.	200 lb. press., 150 deg. superheat, ⅜-in. H.G.	Laidlaw-Dunn-Gordon
1	Dry-vacuum pump	Single-stage rotative	12x33x24-in	200 lb. press., 150 deg. superheat, ⅜-in. H.G.	Laidlaw-Dunn-Gordon
4	Wet-vacuum pumps	Two-stage centrifugal	5-in., 600 g.p.m.	Turbine-driven	H. R. Worthington
4	Wet-vacuum pumps	Two-stage centrifugal	5-in., 600 g.p.m.	Motor-driven	H. R. Worthington
3	W.v.-pump turbines	Kerr	25-hp.	Directly connected	Kerr Steam Turbine Co.
1	W.v.-pump turbine	Curtis	25-hp.	Directly connected	General Electric Co.
4	W.v.-pump motors	Induction	35 hp., 220 volts, 85 amp.	Directly connected	General Electric Co.
3	Circulating pumps	Double suction volute	30-in., 25,000 g.p.m.	Engine-driven	H. R. Worthington
1	Circulating pump	Double suction volute	30-in., 30,000 g.p.m.	Engine-driven	H. R. Worthington
3	Cir.-pump engines	Harrisburg-Fleming	15x16-in. noncondensing	Directly connected	Harrisburg Foundry & Machine Works
1	Cir.-pump engine	Harrisburg-Fleming	16x20-in. noncondensing	Directly connected	Harrisburg Foundry & Machine Works
2	Boiler-feed pumps	4-stage centrifugal	8-in., 1600 g.p.m.	Turbine-driven	Jeansville Iron Works Co.
1	Boiler-feed pump	2-stage centrifugal	8-in., 1600 g.p.m.	Turbine-driven	DeLaval Steam Turbine Co.
1	Boiler-feed pump	2-stage centrifugal	8-in., 1600 g.p.m.	Motor-driven	DeLaval Steam Turbine Co.
1	Boiler-feed pump	4-stage centrifugal	8-in., 1600 g.p.m.	Turbine-driven	Westinghouse Machine Co.
2	Boiler-feed pump turbines		450 hp., 7-stage	200 lb. press., 150 deg. sup. noncondensing	Kerr Steam Turbine Co.
1	Boiler-feed pump turbine	DeLaval-impulse	450 hp., single-stage	200 lb. press., 150 deg. superheat	DeLaval Steam Turbine Co.
1	Boiler-feed pump motor	Induction	450 hp., 4600 volts, 51 amp.	Directly connected	General Electric Co.
1	Boiler-feed pump turbine	Westinghouse	425 hp.	200 lb. press., 150 deg. superheat noncondensing	Westinghouse Machine Co.
4	Heaters	Cochrane-open type	400,000 lb. per hr., 40 deg. to 265 deg.		Harrison Safety Boiler Works
2	Lubricating-oil pumps	Duplex plunger	7x4x10-in.	200 lb. press., 150 deg. superheat	Dean Bros.
2	Lubricating-Oil pumps	Duplex plunger	7½x4½x10-in.	200 lb. press., 150 deg. superheat	H. R. Worthington
2	Step-bearing oil pumps	Duplex plunger	14x3½x18-in.	200 lb. press., 150 deg. superheat	Dean Bros.
2	Step-bearing oil pumps	Duplex plunger	12x3½x18-in.	200 lb. press., 150 deg. superheat	H. R. Worthington
4	Oil filters		Storage 650 gal. capacity 35 g.p.m.	Water-cooled	Turner Oil Filter Co.
2	Accumulators		12-in. diam., 12-ft. stroke, weights 6 ft. diam.	1200 lb. press., one accumulator to two turbines	R. D. Wood Co.
1	Exciter	Type CC, 4-pole d.c.	150 kw., 125 volts, 1200 amp.	2000 r.p.m.	General Electric Co.
1	Exciter	Type CC 4-pole d.c.	125 kw., 125 volts, 1000 amp.	2400 r.p.m.	General Electric Co.
1	Exciter		100 kw., 125 volts, 800 amp.	3600 r.p.m.	General Electric Co.
3	Exciter turbines	Curtis-horizontal	Same as the generator	200 lb. press., 150 deg. superheat noncondensing	General Electric Co.

The Panama-Pacific Exposition—IV

By F. R. Low

SYNOPSIS—The essential features of the Diesel engine are in the cylinder head-valves, and particularly in the spray nozzle. Those of the engine exhibited are described with sectional drawings.

Diesel Engine Cylinders and Spray Nozzles

The essential features of the Diesel engine are in the cylinder, one might say more closely yet in the cylinder head. Sections of the engines are shown in Figs. 16, 17, 18 and 19. The Busch-Sulzer and the McIntosh & Seymour engines have the fuel valve located vertically in the central axis, with the air and exhaust valves on either side and the air-starting valve, where one is used, back of it. In both cases the cylinder is pocketed sidewise, so as to allow the space occupied by the three valves to exceed in width the diameter of the cylinder and to prevent the suspended exhaust and air valves from falling into the cylinder in case of a broken or detached stem. In both cases the fuel and exhaust-valve cages are water-cooled. In the case of the McIntosh & Seymour engine the surface which separates the water from the fuel valve is a thin brass pipe pressed into the casting of the head; in the Busch-Sulzer, a thin cast sleeve. In the Busch-Sulzer the head is separately water-jacketed; in the McIntosh & Seymour the water passes from the barrel through cored passages in the flanges into the head. The Swedish company attributes the fact that it has never had a cracked cylinder head during the thirteen years that it has been manufacturing this type of engine to the more general and even circulation of the jacket water with this arrangement. The lay-shafts and valve mechanism are similar in general arrangement. That arm of the bellcrank which is in contact with the valve stem on the Busch-Sulzer engine is made in two parts, with a diagonal bolt, which may be removed to allow the valve to be taken out. On the McIntosh & Seymour the short section of shaft carrying the cam levers for each cylinder is lifted with its levers by putting a rope sling under its ends, which are grooved for the purpose, the nuts upon the bolts which pass through the ends of the shaft being removed. It is also necessary to unship the spring cap of the fuel valve. The camshaft of the Busch-Sulzer runs in a trough with sufficient oil to keep the cams and bearings well splashed. This

is the trough extending along the front of the cylinders in Figs. 10 and 12. The exhausts are taken off separately and carried below the floor level by vertical water-cooled pipes.

The trunk seen in front of the cylinders in Fig. 11 is the water-jacketed exhaust header into which the exhaust from all four cylinders is discharged and from which it is taken by a single vertical at the end to the basement. This engine is set with its lay shaft and valve gear away from and its exhaust side on the aisle, the Busch-Sulzer with its lay shaft toward the aisle and the exhaust side away from it; hence the similarly appearing trunks occupy the same position to the observer, although they serve widely different purposes and are on opposite sides of their respective engines.

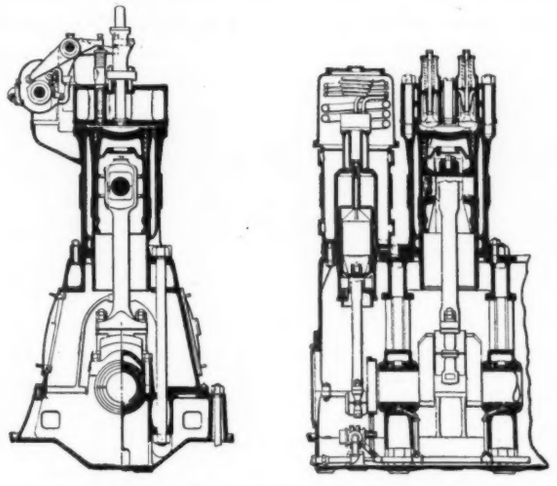


FIG. 16. SECTION BUSCH-SULZER ENGINE

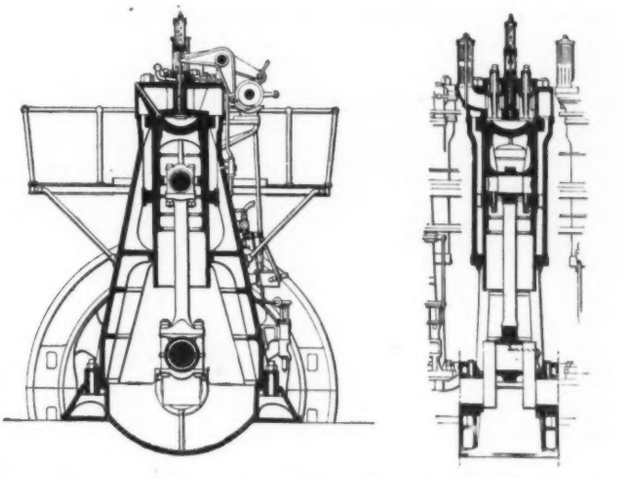


FIG. 17. SECTION MCINTOSH-SEYMOUR ENGINE

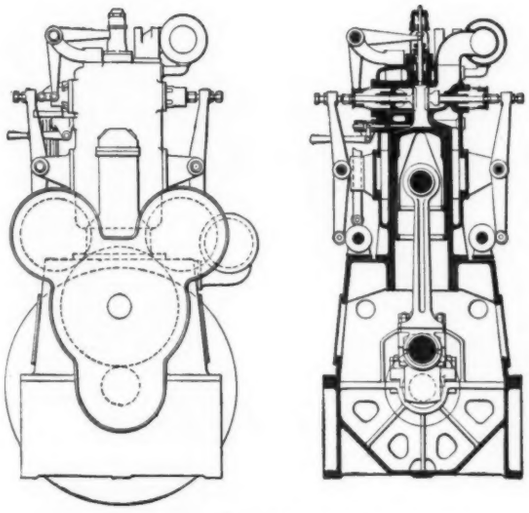


FIG. 18. SECTION NELSECO ENGINE

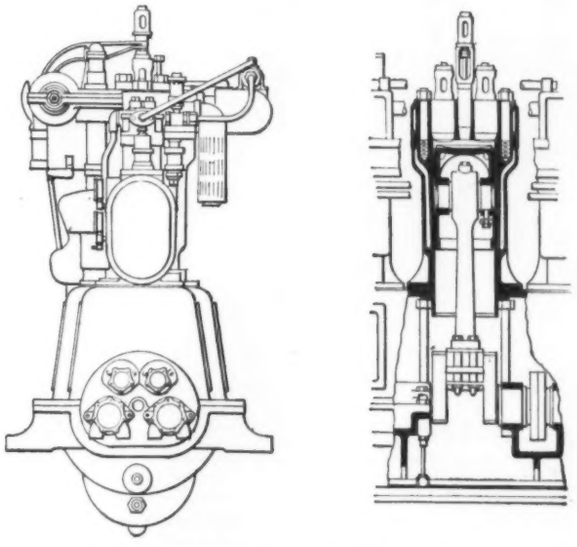


FIG. 19. SECTION FULTON ENGINE

In the Nelseco (New London Ship & Engine Co.) engine (Fig. 13) the fuel valve is also vertical, and in the main axis of the cylinder; but the air and exhaust valves are opposed and horizontal. The cool incoming air impinges directly upon the exhaust valve, avoiding the necessity for water-cooling it, except that the water-jacket of the head is carried up toward, but not around, its stem, as shown in the section (Fig. 18). Separate side-shafts on opposite sides of the engine are used for the air and exhaust valves.

The Fulton engine (which should not be confused with that of the Fulton Iron Works of St. Louis, licensee of the Italian builder Tosi, but not represented at the Exposition) is in its general arrangement a reproduction in miniature, as the section will show, of the larger verticals. It is an application of the Diesel to the smaller marine uses now filled by carburetor engines. At present its maker, the Fulton Engine Co., of Erie, builds only one size of cylinder, 8x9 in., and the largest unit listed is the 100-hp., using six of these. It is also offered for stationary work. A small handle at the free end of the lay-shaft has three positions—barring, starting and running. Push-buttons serve to connect or bypass the fuel for any cylinder when the handle is in the position for running, but are so interlocked with the handle that starting air and fuel cannot be supplied to any cylinder at the same time. With the handle in the barring position, all fuel is bypassed so that the cylinders cannot be overcharged with oil if the engine is turned over several times. A handwheel governs the tension on the governor springs and allows the speed to be changed while running.

It is essential to successful Diesel operation that the fuel should be sprayed into the cylinder in a finely divided or atomized state, so that it will burn almost like a gas. The difference between the Otto and the Diesel

types is that in the former the fuel is taken in on the suction stroke and is all present in the compressed combustible mixture when ignition takes place, the rate of combustion or explosion being limited only by the rate of flame propagation through the mass. This results in an instantaneous increase in pressure; and the type is sometimes characterized as the constant-volume, although combustion does continue after the piston is in motion. In the Diesel type plain air is compressed to a pressure of some 500 lb., attaining by the process a temperature above the ignition point of the fuel. Into this compressed air the fuel is injected under an air pressure several hundred pounds greater than that of compression, through a nozzle which shivers it into a fine mist. This ignites as soon as it reaches the heated inclosure heavily charged with compressed oxygen. Injection takes place when the engine is practically on the center, and continues as the piston moves away, the amount of fuel being regulated in accordance with the load. The idea is that the rate of combustion will be such as to restore the pressure practically as fast as it is diminished by expansion and cooling, and thus the Diesel is sometimes referred to as the constant-pressure type, although many things may conspire to prevent the realization of this condition.

The difference between the pressure produced in the cylinder by compression and that of the injection air is an important factor in determining the rate at which the fuel is injected, and it is necessary to vary the pressure of the injection air with very material changes in the load or for fuels of different degrees of viscosity. To partially accomplish this purpose Sulzer Bros. and their American associates provide the air compressor suction with a throttle which is under control of the governor.

The atomizer used on the Busch-Sulzer engine is that employed by Sulzer, and, in type at least, by most of the Diesel licensees. It is shown in section in Fig. 20. The charge of oil for the coming stroke is delivered to the chamber *C*, which is continuously in connection with the bottle containing the high-pressure injection air. At the bottom of this chamber are disks *D* with perforations which do not register, so that when the fuel valve *B* opens, the oil coming through one of the perforations of the top plate is driven against the solid portion of the next plate with a velocity induced by a difference of pressure of some 400 or 500 lb., and is broken up into a spray, in which form it is swept through the successive plates, becoming finely atomized. The truncated cone *E* below these disks is grooved on its outer surface, and the oil-laden air passes through these grooves and is directed against the edges of the opening in the nozzle plate in such a manner that its stream, upon entry into the combustion chamber is spread into a saucer-shaped flame all over the surface of the piston.

The atomizer used on the McIntosh and Seymour engines is that invented by K. H. E. Hesselmann of the Aktiebolaget Diesels Motorer. This atomizer has been tried out with various American oils and gives smokeless exhaust and perfect combustion under a wide range of loads, even with Mexican oils as heavy as 14 deg. Baumé. With ordinary oils the excess of atomizer air

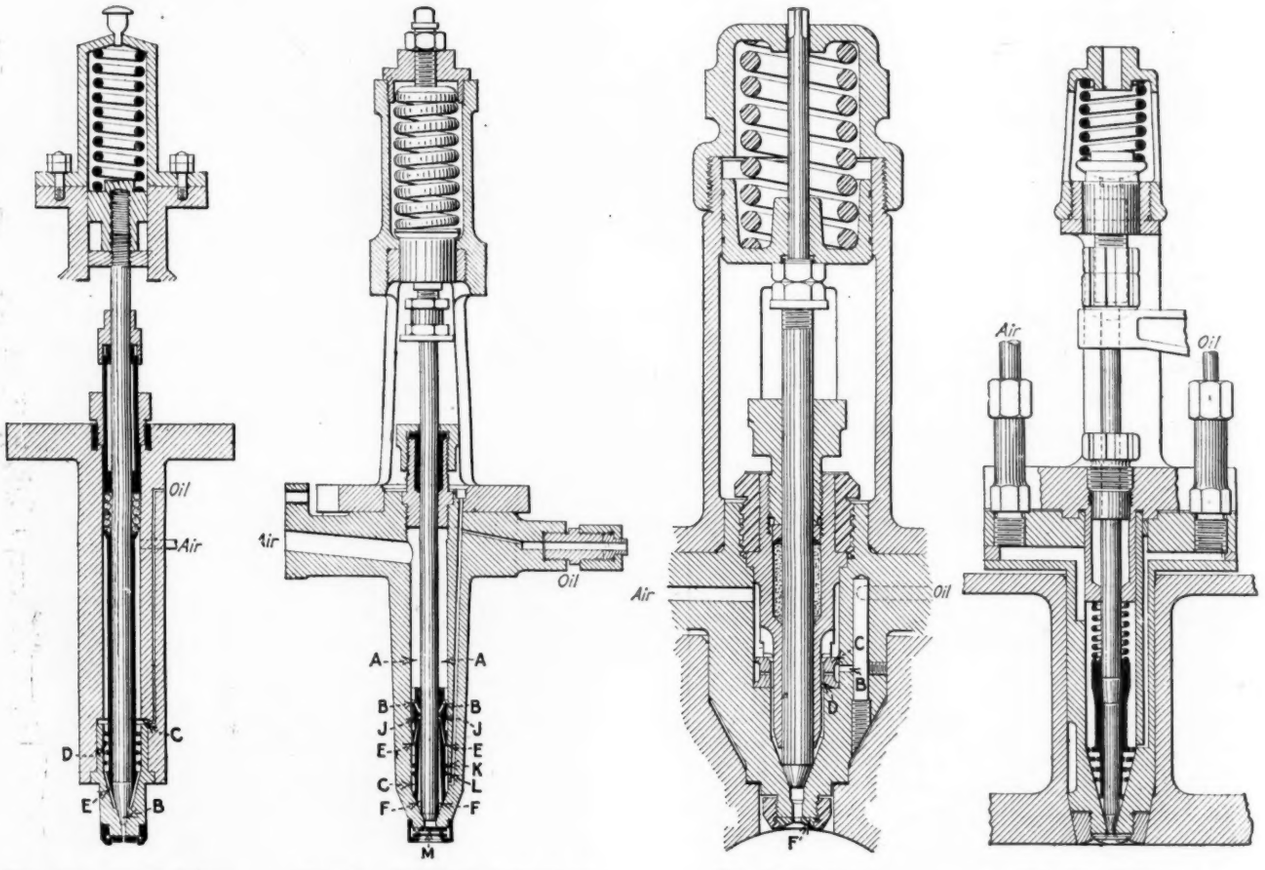


Fig. 20. Busch-Sulzer Fig. 21. McIntosh & Seymour Fig. 22. Nelseco Fig. 23. Fulton

FIGS. 20 TO 23. SPRAY NOZZLES, ATOMIZERS ON FUEL VALVES FOR DIESEL ENGINES

pressure above compression pressure runs less than 300 lb. Its essential feature is that instead of pulverizing the oil by crowding it down through perforated plates it draws it by the injector principle into the current of ingoing injection air, which atomizes and absorbs it as fast as it is drawn up. In Fig. 21 the charge of oil is deposited in chamber *C*, which it does not fill, even at an overload. Air is admitted to the chamber *A* and passes through the ports *B*, while it has also access to chamber *C* through the space *EE*. When the fuel valve opens, the air, rushing through the port *BB*, passes through the expanding passage *FF* between the valve stem and the receding wall of the surrounding fitting, induces by injector action a difference of pressure which causes the oil to flow to the space *JJ*, into which the oil, having been elevated and broken up through the slotted plates *K* and *L*, is drawn and picked up by the ingoing air. The form of the fuel plate *M* has an important effect upon the efficiency of the atomizer.

That to which the spray nozzle used on the Nelseco engine belongs has been called the "straight-passage" type, because the fuel does not pass through a perforated atomizer. Entering at *B* (Fig. 22), the fuel is deposited by means of a distributing ring *C* in the annular space *D* between the spray needle and the valve body, and when the valve opens the fuel is blown straight through, being effectively pulverized by passing at high velocity through the chambers of changing diameter between the end of the spray needle and the burning plate *F*.

The atomizer of the Fulton engine appears to be of the same accepted Diesel type as that used on the Busch-Sulzer.

Lovekin Marine Boiler and Internal Superheater

By Rear Admiral A. B. Willits, U. S. N.

SYNOPSIS—A new type of Scotch marine boiler having a superheater within the shell. For a given output the boiler weighs less and occupies less space than common makes of Scotch.

In marine practice modern demands for speed, and space for cargo or equipment, have compelled marked changes in the steam-engineering departments of vessels, within the last decade or two, wholly apart from those involved by the advent of the turbine. Hull conditions have imposed the task of installing power plants of the maximum safely obtainable horsepower per ton and per cubic foot of space allowed. Mechanical problems involving strength of material, packing, lubrication and abrasion have limited the steam pressures and degree of superheat which has been found possible to utilize with economy and efficiency, but a steam pressure around 300 lb. is not uncommon in late warships and fast steamers.

The heart of the power plant is the steam generator, and in meeting the modern conditions the old type of marine boiler, the Scotch, found itself confronted with difficulties. To produce the greatest output of steam from a given grate area (the starting point in boiler design) it was necessary to burn efficiently the greatest amount of coal possible per square foot of grate, and this called for the installation of a forced-draft system. To properly absorb the increased number of heat units per hour thus developed, it was further necessary to increase the heating surface, which consisted mainly in adding to the number of tubes. This increase in heating surface demanded a proportional increase in diameter of shell to retain a proper amount of steam space, and the increase in diameter of the shell involved, even for the same pressure, an increased thickness of the metal of the shell, with consequent addition of weight due to each of these increases. The use of higher pressure further increased the shell thickness; and it is not difficult to conceive of a limit to diameters and pressures, as the shell thickness would soon become prohibitive. This limit is approached at 15 ft. diameter for 200 lb. steam pressure, yet the water-tube boiler, with its greater flexibility in steam generation, has stepped in, not only to bring safely usable pressures up another hundred pounds or so, but also to produce results above the reach of the Scotch boiler.

But the latter still continues to have its advocates and users by the thousands, and for good reasons. It has been plodding along like an old turtle, in the rear of the column, and "pokes its head in" at the conferences whenever the procession halts. It has a great number of advantages, especially when the force of attendants is not of the highest skill or intelligence. Its large water volume, makes water tending less strenuous than with water-tube boilers. It is a tough and persevering "shade" that can stand more punishment, and come up smiling, than any other boiler built. It can recover from the most severe "surgical" operation, even if this be performed by the unskilled. Anything that brings to the Scotch boiler increased efficiency, without making it more complex, while reducing diameters and weights for equal output and pressures, is of interest.

One of the inherent defects of the Scotch boiler is its uneven distribution of ebullition, due to the differences in the heat transmitted through its heating surfaces. The tops of the furnaces, tops of back connections or combustion chambers, and the ends of the tubes at these chambers form surfaces from which the most violent ebullition starts; while the intensity with which steam is formed decreases as the distance from these parts increases. There occurs upon a quite uniform surface a most nonuniform production of steam bubbles, which, in the most violently agitated part, invariably entrain water that, when the demand upon the boiler is near its capacity, has no time for deposition before entering the dry pipe en route to the engines. Frequently the result is injury to piping or machinery; sometimes it is disastrous, and it is always wasteful of heat.

Now, no boiler with entirely submerged tubes can deliver perfectly dry steam, and even the water-tube boiler

of the form most favored requires its superheater for best results. The degree of superheat common is not yet really high, but that which will insure dry steam throughout the engine-cylinder passage is demanded. No superheater, however, will dry out steam entraining such quantities of water as at times embarrass the Scotch boiler, and the problem was to provide for separation of this water as well as to superheat the steam itself before it leaves the boiler.

The Lovekin boiler, invented by L. D. Lovekin, of the New York Shipbuilding Co., Camden, N. J., does this.

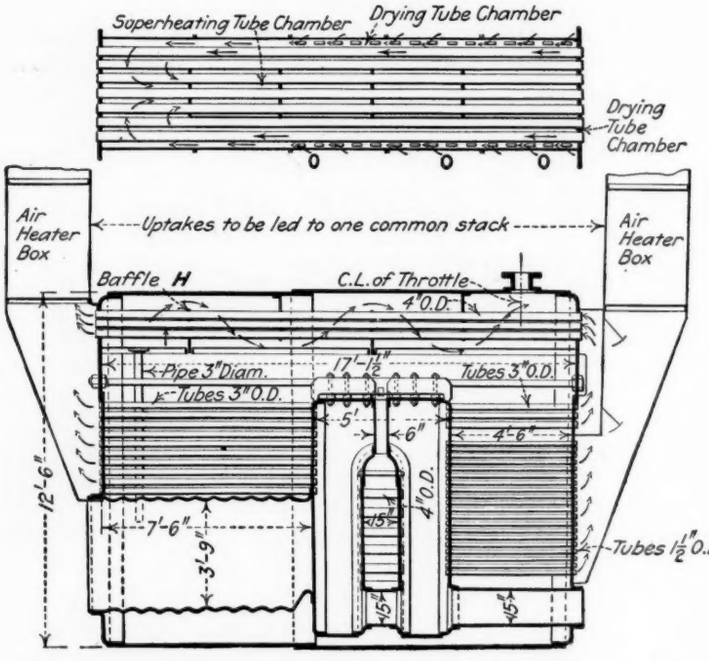


FIG. 1. THE NEW LOVEKIN SCOTCH MARINE BOILER AND SUPERHEATER

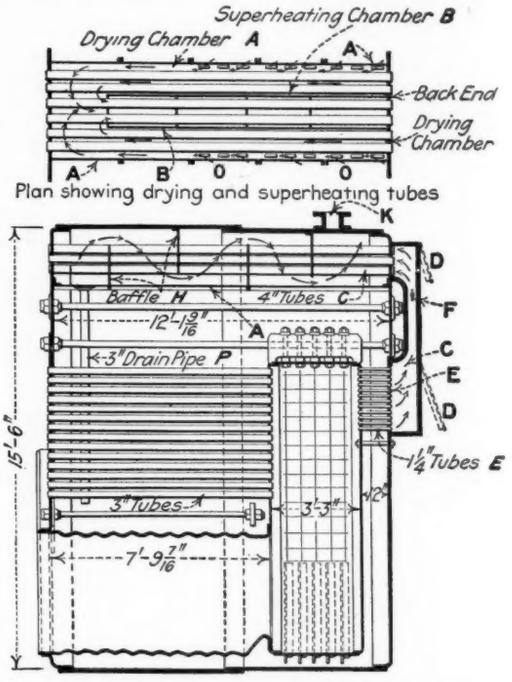


FIG. 2. THE LOVEKIN SUPERHEATER ON ORDINARY SINGLE-ENDED SCOTCH BOILER

The boiler, with superheater, is shown in Fig. 1. A close study of this drawing will be all that is necessary for an understanding of the features of the boiler; the superheater will be described in detail. The novel arrangement of the heating surface of the boiler permits of a design which, for a given output of steam per hour, will have less diameter of shell, less length and considerably less weight than will the usual Scotch type. This has been carefully worked out for a ship estimate for a set of six cylindrical boilers, oil-burning, to be installed in two athwartship rows of three each. The data resulting clearly show the advantages of the Lovekin boiler.

DATA FOR SIX OIL-BURNING BOILERS

	Ordinary Type	Lovekin Type
Furnace arrangement	Double-ended	Single-ended
Diameter of boiler	14 ft. 5 in.	12 ft. 6 in.
Length of boiler	19 ft. 7 in.	17 ft. 0 in.
Number of fire rooms	Three	One
Evaporation required lb. water per hr.	160,000	160,000
Total heating surface, sq.ft.	26,500	26,500
Total weight of boilers, dry, lb.	930,000	696,000
Total weight of water, lb.	430,000	360,000
Total weight boiler and water, lb.	1,360,000	1,056,000

The superheater is obviously applicable to any horizontal cylindrical boiler, and in Fig. 2 it is shown in the ordinary single-ended Scotch type, very similar to the boilers now being installed in a collier at the New York Shipbuilding Co.'s works, and with which the first tests in service will be made of the superheater. Fig. 3 shows a cross-section of the superheater.

To form an effective superheater within the boiler shell, it is plainly necessary to use an inclosed chamber separate from the usual steam space, that the effect of reheating or superheating the steam may not dissipate into that space and lose its direct effect upon the current flowing to the engine. The Lovekin design, for this reason, is a two-part inclosure of boiler steel, located in the highest part of the boiler; the outer box *A*, Figs. 2 and 3, being the dryer box and the inner box *B* the superheater. Box *A* extends from end to end of the boiler, its top and its two ends being formed by parts of the boiler shell and heads. This outer box has no communication with the steam space of the boiler except through a series of slots *O* in its two sloping side sheets, extending from the back end to about midway of its length. It has however, connection with the water space of the boiler by two drain pipes at the front end of its bottom sheet, one on each side, through which the water separated from the steam entering this chamber falls to the boiler-water level.

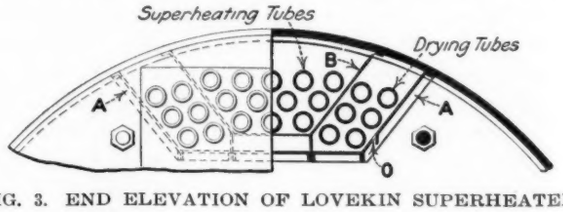


FIG. 3. END ELEVATION OF LOVEKIN SUPERHEATER

Within the dryer box is a smaller box *B* of similar section, which is the superheater chamber. It extends from the back of the boiler to about four-fifths of the distance to the front head and has no communication with the outer box except through its open front end.

Through each box pass six stay-tubes, secured to the front and back boiler-tube sheets, or heads, and carrying

portions of the hot gases from the combustion chamber to the front connection, or uptake. These tubes are fed from the combustion chamber by means of a number of small tubes *E*, Fig. 2, passing from the chamber through the water space to a small added back connection *C* leading up to the back ends of the superheater stay-tubes. These small tubes also add to the heating surface of the boiler proper. The small back connection *C* is provided with a damper *F* which has a regulator. Doors *D* permit of ready adjustment of the flow of gases, the admixture of atmospheric air with these gases above the damper, and the cleaning of the tubes.

The operation of the superheater is as follows: Steam enters the outer chamber *A* through the slots *O*, in a more or less wet condition. To reach the point of exit (stop valve opening *K*) it has to first travel over the tubes in *A*, from points of entrance through the slots to the opening at the front end of *B*, and in this course the steam is dried appreciably. At the open end of *B* the current is reversed, and the entrained water is thereby separated and deposited upon the front head of the bottom sheet of the outer box and flows down the drain pipes *P*. The quite dry steam now entering the superheater box is, by a suitable arrangement of baffle plates *H*, forced to traverse the surface of the superheater tubes several times before it can reach the exit orifice *K*. It is readily seen that in this passage a considerable amount of superheat can be given to the steam and that the prime requisite of dry steam is assured, together with the economic advantages of superheat.

As to the stresses caused by expansion of the superheater tubes, which might at first glance be thought overtaxing, it will be noted that the upper part of the boiler shell in this type receives considerable heat from the uptake gases that flow over the front heads and ends of the upper shell courses, and this heat is transmitted along the shell, resulting in an abnormal expansion of the top of the boiler. On the other hand, the gases flowing through the superheater tubes will not be of the temperature of the gases in the combustion chamber, but will be modified, not only by the temperature of the surrounding superheated steam, but also by decreased flow due to the damper and by such admixture of atmospheric air as will be found proper to maintain simply that increase in the sensible heat of the steam as will answer modern requirements.

The invention promises to add materially to the economic performance of the Scotch boiler, and data from the trials of the collier referred to will be looked for with more than passing interest.

Visits of Inspector Brown--IV

By J. E. Terman

SYNOPSIS—Brown seeks information regarding boiler draft, and as to how the area between the baffles and the header is figured with water-tube boilers employing horizontal baffling.

Brown, coming into the Chief's office one day after lunch, brought up the subject of boiler draft. The Chief happened to be preparing specifications for a stack desired by a customer and said that he would probably get some ideas in discussing the subject with Brown.

"You remember sending me to make a special inspection of three water-tube boilers at the Schwartz brewery about a week ago," said Brown, "to see of I could find out why they were having trouble in keeping up steam?"

"Yes," answered the Chief, "and I have been wondering why you have not reported sooner."

"Well, Chief, the reason I did not report before was because I did not know how the changes that I recommended to the engineer would pan out. I first wanted to find out what the results were and I thought it would then be time to write my report to the Schwartz people."

"I knew that you were getting pretty smooth," said the Chief, "but the constant contact with trouble incidental to the occupation of boiler inspecting has wonderfully developed your bump of caution. How do you know that the chief engineer will not claim the credit for any improvement in the operation of the plant if your recommendations prove beneficial?"

"I had thought of that," answered Brown, "but I would rather let the engineer get the credit for any benefits derived than to be too eager to claim the credit for bad advice. I have been there today and I find that the change I recommended was a success and I would like to have you tell me why it was. The first thing I did at the plant was to ask the engineer if he was burning the same amount of coal under each boiler, for I had not forgotten the instructions you gave me some time ago, to see that each boiler was doing its share of work in a plant where there was a lack of boiler capacity. All three of the boilers at the Schwartz brewery are of the same size, and of course each furnace should burn the same amount of coal.

"The engineer did not know how much coal was burned under each boiler, but the fireman said that No. 3 consumed less than either of the other two, and as the boilers were prepared for inspection, I examined them with special care to determine if there was any reason why the draft should be different in No. 3. I had expected that the location of that boiler might be one cause of unequal draft, because it was the farthest away from the stack, and I also thought that the dampers in the uptakes might be improperly set, but they appeared to be all right. And the fireman said that they were never moved.

" I could not find any difference in the draft passages until I reached the rear combustion chamber of No. 3 boiler. There I found that two extra rows of baffle tile had been added to the horizontal baffle, leaving a space of about fourteen inches between the rear end of the baffle and the rear header of the boiler. Nos. 1 and 2 boilers had a space of about three feet between the rear ends of the baffle and the header, and I concluded that this restriction to the passage of the gases was the probable cause of the trouble. I suggested to the engineer that he remove two rows of baffle tile in this boiler and note the results. He did so and now they have all the steam they require.

"Now, what I want to know is, how do you arrive at the proper distance between the baffles and the headers in the case of a horizontally baffled, water-tube boiler? I know that in the case of a horizontal-tubular boiler the area over the bridge-wall and in the uptake connection, as well as the area of the smoke flue, is based on the internal cross-sectional area of the tubes, and while this is a simple problem to figure out in this type of boiler, it is not so easy in the case of a water-tube boiler. There is no space between the tubes for the passage of the gases that can be used as a basis for figuring, unless it is the space left by the erector, which would be absurd.

"How do boiler manufacturers know how much space should be left for the passage of the gases from the furnace to the uptake? I happened to hit the trouble at the brewery, only because one of the boilers was not doing its full duty, but if all the boilers had been baffled alike, I would not have known just how much space should be left at the ends of the baffles. I would have known from past experience with other boilers of this type that 14 in. was not enough, but I do not know now that the space which has been left is the one that will give the best results."

"Well, Brown," said the Chief, "I think that you have used your head to good advantage in diagnosing the trouble at the brewery, and I would advise you to continue along the same lines in dealing with future cases of a similar nature. As you state, you should know how to figure the proper space for the escape of the gases from the furnace to the stack, and I will endeavor to help you solve this problem as far as I can.

"In the first place, it will be necessary for you to forget some of the things that you have apparantly absorbed from the other inspectors in connection with the proper method of figuring the gas passages for a horizontal return-tubular boiler. There is no exact or real relation between the internal cross-sectional area of the tubes in a horizontal return-tubular boiler and the flue area necessary to serve it.

"Returning to the problem under discussion, I will say that there is no definite answer, because it is dependent on so many conditions with regard to the intensity of draft and the kind of fuel to be burned, as well as the particular kind of boiler to be considered. It is necessary in all cases to have the baffling for a boiler so arranged that the gases from the furnace will be passed over practically all of the water-heating surface and without the formation of pockets of dead gas or short-circuiting at any point. The heating surface of a boiler is the primary factor in determining the amount of area necessary for the gas passages, because it indicates the amount of fuel to be burned and therefore shows the volume of gas to be handled in a given time. The average water-tube boiler, when operating at its rated capacity, should show a drop in draft between the furnace and the uptake connection of, say not more than three-eighths of an inch of water, and if the drop is much more than this, where the draft available is too small to properly consume the required amount of fuel to obtain the desired capacity, the baffling of the boiler should be looked after.

Many of the cases of draft troubles such as you have found at the brewery are due mainly to the lack of proper distribution of the available draft between the boilers served. Whether there is little or much draft available, it should be properly distributed to the boilers in order to obtain maximum capacity and economy. Most of the troubles caused by the improper distribution of draft among several boilers may be overcome by the use of individual dampers; in fact, that is the real use to be made of them and not merely to be closed when the boiler is idle and opened wide when it is in use. A proper test of the distribution of draft does not mean that the draft for each boiler is the same, for where different kinds or sizes are used one may require more draft than another, in order to burn the required amount of fuel to generate its proper share of steam. The real test of the proper distribution of draft is the one which you have applied at the brewery plant; that is, the proper proportion of coal burned under each boiler in relation to its size. If the distribution by this test is found to be faulty for any boiler, then the baffling and passages for the gases from the furnaces to the main flue should be examined to determine what correction is necessary.

"There is one thing, Brown," said the Chief, "that I want to explain more fully while we are on this subject, and that is in regard to the proper method of figuring the area of gas passages for horizontal-tubular boilers. I can possibly explain this to the best advantage by asking you a question. If you should have two such boilers placed side by side, each containing the same number of tubes of equal diameter, but one boiler 12 ft. and the other 24 ft. long, you would expect the longer boiler to develop about twice the capacity of the shorter one, wouldn't you?"

Brown admitted that he would.

"Well," continued the Chief, "if that is so, it would require about twice the amount of fuel burned under it, which would mean that there would be about twice the volume of gas to be handled for the larger boiler, and if the area of the passages for this gas was proportioned according to the cross-sectional area of the tubes it would be the same for both boilers.

"Another thing in connection with such an arrangement is that the resistance to the passage of the gases through the longer boiler would be higher, on account of the relatively smaller cross-sectional area and the longer passage through the tubes, and this could only be compensated for by having relatively less friction in the other gas passages for this boiler or by manipulating the individual dampers on the boilers.

"There are many points in connection with the subject of draft for boilers," said the Chief.

Just then the telephone rang and when the Chief had answered the call he told Brown to go over to the distillery and see if he could tell them what was the matter with the water column on the No. 1 boiler, which had been reported over the phone to be acting queerly.

Use of Electrically Driven Auxiliary Machinery

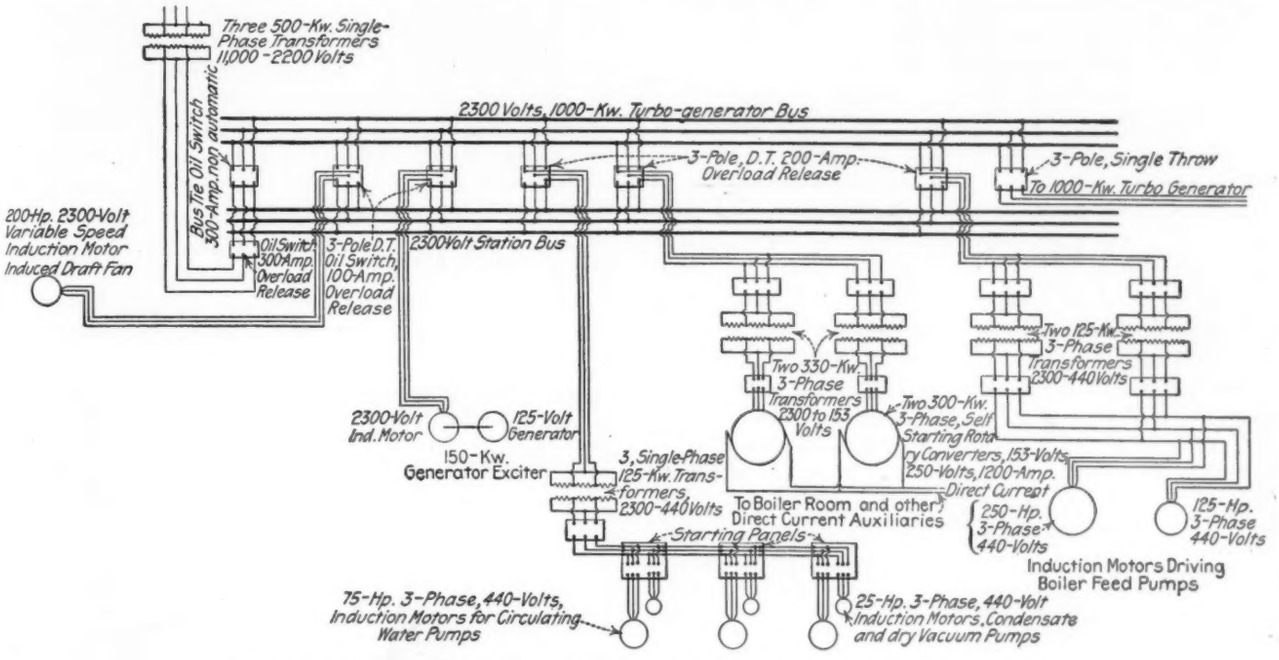
By A. D. Williams

An argument against the use of electrically operated auxiliary machinery in power plants designed to supply continuous service has been that line troubles that affect the operation of the generators are liable to cut down the speed of the auxiliaries or shut them down just at the time when they are needed. In designing the Cleveland municipal plant, F. W. Ballard, commissioner of light and heat, has provided for this possible con-

tingency by the installation of a 1000-kw. turbo-generator, which supplies for the auxiliaries a source of energy entirely independent of the main units. The machine used for this purpose was originally installed in the South Brooklyn municipal plant, the operation of which was abandoned shortly after the East Fifty-third Street plant was placed in operation.

The diagram shows the general arrangement of the switchboard and power circuits for the auxiliary machinery. This switchboard is provided with two sets of interconnected 2300-volt busbars, one set being connected to the 1000-kw. generator through a single-throw oil switch and the other set energized from the main units through three single-phase transformers which step the voltage down from 11,000 to 2300. When the station was first placed in operation the main units were the only source of current available for operating the auxiliaries and it was necessary to provide against interruptions. By using three single-phase transformers connected delta, instead of a three-phase transformer, one may be cut out and the other two used in open delta to keep the bus alive should anything happen to the third transformer.

Power is taken off for the various circuits through double-throw oil switches with overload release, so that either busbar may be used or the load divided between them. A portion of this power is used for 2300-volt motors, but for the motors operating the circulating pump, the dry-vacuum pump and the boiler-feed pumps, it is stepped down to 440 volts, and to 133 volts for the rotary converters which supply 250-volt direct current. This last service is used for those motors which require a closer speed control than is possible with induction motors.


Three 500-Kw. Single-Phase Transformers 11,000-2200 Volts
Bus Tie Oil Switch 300-Amp. non automatic
2300 Volts, 1000-Kw. Turbo-generator Bus
3-Pole, D.T. 200-Amp. Overload Release
3-Pole, Single Throw To 1000-Kw. Turbo Generator
200-Hp. 2300-Volt Variable Speed Induction Motor Induced Draft Fan
Oil Switch 300 Amp. Overload Release
3-Pole D.T. Oil Switch, 100-Amp. Overload Release
2300-Volt Station Bus
Two 330-Kw. 3-Phase Transformers 2300 to 153 Volts
Two 125-Kw. 3-Phase Transformers 2300-440 Volts
2300-Volt Ind. Motor
125-Volt Generator
150-Kw. Generator Exciter
3, Single-Phase 125-Kw. Transformers, 2300-440 Volts
Two 300-Kw. 3-Phase, Self Starting Rotary Converters, 153-Volts, 250-Volts, 1200-Amp. Direct Current
To Boiler Room and other Direct Current Auxiliaries
250-Hp. 3-Phase 440-Volts
125-Hp. 3-Phase 440-Volts
Induction Motors Driving Boiler Feed Pumps
Starting Panels
75-Hp. 3-Phase, 440-Volts, Induction Motors for Circulating Water Pumps
25-Hp. 3-Phase, 440-Volt Induction Motors, Condensate and dry Vacuum Pumps

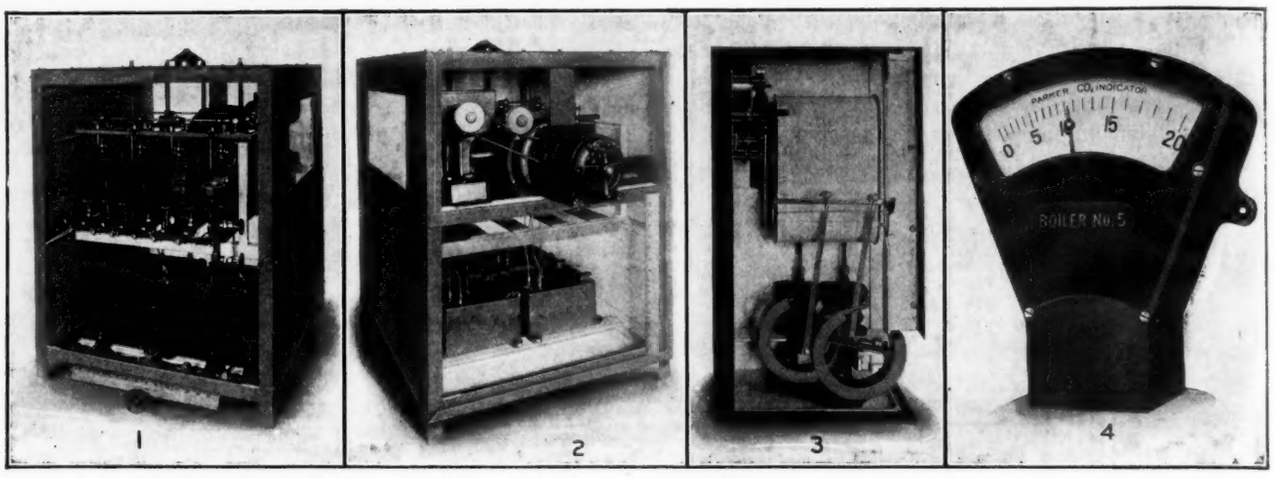
WIRING LAYOUT FOR AUXILIARIES AT CLEVELAND MUNICIPAL PLANT

New Parker CO_2 Machine

SYNOPSIS—A description of a mechanical CO_2 machine that differs radically from any other. The indicator may be placed on the boiler front, and the recorder in the office or at any other convenient point.

A mechanical CO_2 machine differing radically from any other device which has hitherto been used has been perfected by H. C. Parker and is now being made by the Precision Instrument Co., of Detroit. As the illustrations show, there is no glass or rubber tubing. Accuracy, durability and need of minimum attention from the engineer are the features which the inventor has endeavored to incorporate in the machine. It is to be built in units of from one to six, and either separate indicators or separate recorders can be placed in any position desired irrespective of the location of the machine. For example, the indicator may be placed on the boiler front, and the recorder in the office or at any other location.

The gas to be analyzed is drawn in a continuous stream through a pump of special design by a small suction fan. Part of the gas is taken up by the pump and the remainder discharged to the atmosphere. From the pump the gas passes into an absorption chamber where the CO_2 is removed. A second pump having the same capacity as the first draws the remainder of the gas from the absorption chamber and also a volume of air from the atmosphere equal in volume to the CO_2 gas absorbed. The volume of air replacing the CO_2 gas is measured by drawing it through an orifice and noting the difference in pressure at the two sides. Sensitive vacuum gages calibrated to read the percentage of CO_2 directly are used for the purpose.



PARKER CO_2 MACHINE AND THE INDICATING AND RECORDING INSTRUMENTS

Fig. 1—Parker CO_2 machine. Fig. 2—Driving end of machine showing small motor employed. Fig. 3—A two-record recorder. Fig. 4—The CO_2 indicator

Figs. 1 to 4 show the CO_2 machine and the indicating and recording instruments. Fig. 5 shows the connections of the system and Fig. 6 the construction of the various parts of the machine. Its operation may be described as follows:

A small suction fan maintains a constant flow of gas from the uptake of the boiler through a special pump *A* (Fig. 6), which is filled with oil to the point shown. The buckets *B*, which are made of tubing, are mounted on a hub *C*, which makes one revolution in about thirty seconds in a clockwise direction. As the buckets rise above the surface the oil is gradually discharged through tube *E* into the passage *F*, from which it flows back into the main body of the pump through the opening *H*. As the oil disappears gas enters the bucket through the opening *D*, and when the bucket reaches its highest point of rotation it is completely filled with gas. When the bucket passes beneath the surface of the oil, the gas is sealed off in the

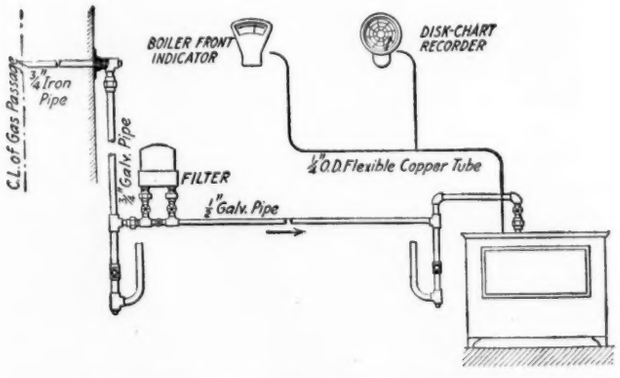


FIG. 5. DIAGRAM OF PIPING CONNECTIONS

bucket and is carried down until the opening *D* is below the outlet of *E*. Then the gas is pushed out of the bucket by oil entering through *D*. With six buckets in operation a continuous stream of gas bubbles up through the passage *F*. The oil in the pump prevents the gas from getting into the passage *F* except through the buckets and also prevents air from entering around the vertical shaft *I*.

From the pump *A* the gas goes to the absorption chamber *J* where the baffles force it to follow a long path through a caustic potash solution, which is constantly stirred by a small vane mounted on the vertical shaft *K*.

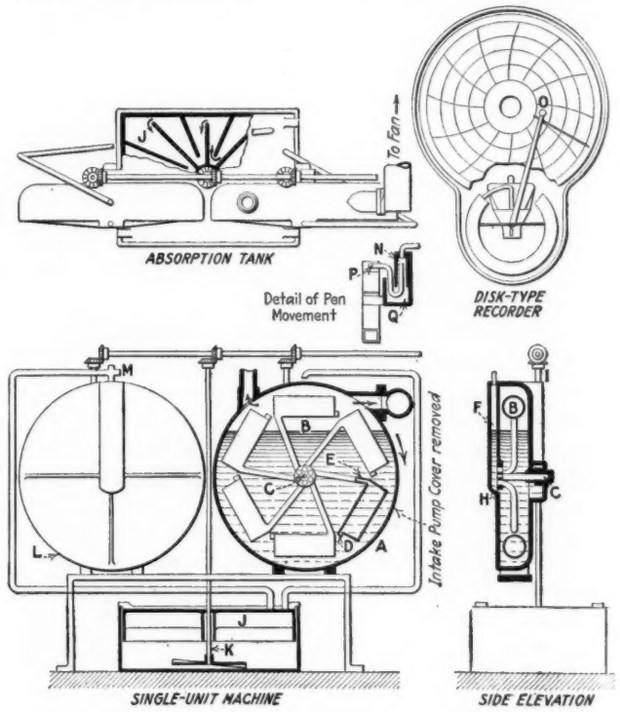


FIG. 6. CONSTRUCTION OF PUMP, ABSORPTION TANK AND RECORDING INSTRUMENT

From the absorption chamber the gas passes to the pump *L*, which has the same capacity as the pump *A*. If any gas is removed in the absorption chamber, the pump *L* produces a vacuum which draws air through the orifice *M*. The volume of this air is the same as that of the CO_2 absorbed, and the vacuum required to draw the air through is proportional to the volume of air and consequently to the volume of CO_2 absorbed. The vacuum or rather the percentage of CO_2 is recorded by means of a U-tube mounted on knife edges and carrying the pen *O*. One side of this tube is open to the atmosphere; the other end is closed except for its connection to the tube *P*, which passes into the pressure chamber *N* through the mercury seal at *Q*. The U-tube is filled about half full of oil and when the vacuum in the pressure chamber *N* is zero, the U-tube swings the pen to the zero line. As the vacuum increases the oil is drawn up on the closed side of the U-tube and down on the open side, making

the closed side heavier and causing the U-tube to swing. The tube is counterbalanced and the chart calibrated so that the vacuum caused by a certain volume of CO_2 gas absorbed swings the pen to the proper line for that volume on the chart. To eliminate friction, the pen is set to swing free from the chart except at intervals of sixty seconds, or more often if desired, when it is pressed against the paper by the rod shown in the drawing. Consequently the record is a dotted line.

The suction fan which discharges all gas to the atmosphere not taken up by the pump *A* is driven by a ⅛-hp. motor designed for either alternating or direct current. The gas-sampling tube shown in Fig. 5 is placed in the uptake or the last pass of the boiler. It is a ¾-in. iron pipe, with a beveled end placed toward the flow of gas. At the end of the sampling pipe is a filter for removing the particles of ash which might be drawn into the apparatus. A ½-in. galvanized pipe connects the filter to the machine. It will be noticed that open end U-tubes are provided to drain any condensation which may collect in the piping. Flexible copper tubing of ¼-in. outside diameter connects the instruments to the machine.

Comparison of Chimney Sizes

By J. C. Lathrop*

In connection with the design of a large power station during the last year the following compilation of data relating to the size of chimneys used in recent installations was made as an approximate guide to current practice for large power stations.

SIZES AND CAPACITIES OF LARGE CHIMNEYS IN VARIOUS SECTIONS OF THE UNITED STATES

No.	Location	No. of Boilers Served by Stack and Hp.	Type of Stoker Installed	Inside Diam., Ft. and Inches	Inside Area, Sq.Ft.	Height Above Grates, Ft.	Capacity Kent Formula, Hp.	B.Hp. Connected	B.Hp. per Sq.Ft. of Chimney
1	New York	24–650	Taylor	21–0	345	250	17,600	15,600	45
2	Baltimore	12–1000	Taylor	20–2	320	250	16,200	12,000	38
3	Akron, O.	16–600	Taylor	16–0	200	275	10,600	9,600	48
4	Boston	8–600	Taylor	13–0	132	210	6,000	4,800	36
5	Milwaukee	2–765	Taylor	8–0	50	125	1,710	1,530	31
6	Indianapolis	20–520	Roney	18–0	254	300	14,100	10,400	41
7	Georgetown	6–600	Roney	11–0	95	225	4,450	3,600	38
8	Utah	6–600	Roney	11–6	104	220	4,820	3,600	35
9	Meriden, Conn.	4–625	Roney	9–0	64	150	2,420	2,500	39
10	Chicago	8–1220	Chain grate	19–0	284	250	14,400	9,760	36
11	Venice, Ill.	12–600	Chain grate	12–0	113	200	5,050	7,200	64*
12	Chicago	10–580	Chain grate	17–0	227	250	11,500	5,800	26
13	Perth Amboy	8–600	Chain grate	14–0	154	180	6,550	4,800	31
14	Louisville, Ky.	8–507	Chain grate	13–0	132	255	6,660	4,050	31
15	Savannah, Ga.	4–700	Chain grate	10–0	78	230	3,660	2,800	36
16	Altoa, Ill.	4–440	Chain grate	12–0	113	150	4,350	1,760	16†
17	Waterloo, Ia.	5–300	Chain grate	7–0	38.5	135	1,350	1,500	39†
18	Lexington, Ky.	8–500	Murphy	12–0	113	210	5,150	4,000	35
19	Gadsden, Ala.	6–600	Murphy	13–0	132	225	6,250	3,600	27
20	Fruitvale, Cal.	12–645	Oil burner	14–6	165	125	.....	7,740	47
21	Jacksonville	12–520	Oil burner	12–0	113	180	.....	6,220	53
22	N. Shore, Cal.	3–265	Oil burner	5–0	19.5	70	.....	795	40

* Six boilers in place. † Induced draft provided.

The twenty-two plants used for this purpose were selected at random from descriptions given in various technical periodicals during the last three years. In a number of instances the full number of boilers given in the tabulation has not been placed, but provision has been made for their future installation. It will be noted that plant No. 11 gives 64 b.hp. per sq.ft. of chimney. Only one-half the boilers are in place, but an additional breeching connection has been provided. It would seem that the designer when deciding upon the size of the chimneys did not provide for additional boilers.

On the other hand, in plant No. 16, where but 16 b.hp. are allowed per sq.ft., provision has been made for forced draft. In view of the general practice shown by this tabulation, this would be unnecessary even when the boilers were forced to 200 per cent. or more of normal rating. The boiler horsepower per square foot of chimney for the first group is higher than any of the others. As the stokers are of the under-feed type, from which boiler outputs of from 200 to 300 per cent. of rating are common, it would seem that the size of chimneys to be used for such plants should be determined largely by local considerations.

It is interesting to note that the stacks for plant No. 4 were designed so that 50 ft. could be added if found necessary after all the boilers were in operation. To the best of the writer's knowledge this addition has not been made.

Groups Nos. 2 and 3, in which Roney stokers and chain grate stokers were used, have an average of 38 b.hp. and 35 b.hp. respectively per square foot of chimney. However, if plants No. 11, No. 16, and No. 17 are omitted the averages come close to 32 b.hp. for each type.

Only two plants were considered where Murphy stokers are used. These are given in group No. 4 and have an average of 31 b.hp. per sq.ft. of stack.

The plants listed in the fifth and last group, which use oil for fuel, have about 50 per cent. more boiler horsepower per square foot of stack than any of the others. It is well known that oil-burning plants need much less chimney capacity than those using coal. Not only is a smaller area per boiler horsepower required, but the height need only be sufficient to carry the gases above the surrounding buildings.

The valuable information that may be obtained from a table of this kind, when combined with information regarding the results obtained during the operation of one or more of the stations, may be illustrated by considering the design of the stacks for plant No. 4. If the designer could have been sure that the future additions of 50 ft. to each stack would not be necessary, a saving of thousands of dollars would have been possible on foundation, steel supporting structure, and metal in the steel shells.

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Engineers in the Legislature—One way to get license legislation is to put men in the legislature who will pass it. Engineers and those who believe that the boilers over and about which they and their children pass and live should be under the charge of competent, careful men are interested in the candidacy of Henry F. Burns as assemblyman for the Sixteenth District of New York. Mr. Burns is a practical engineer and at present an inspector of the American Compensation Insurance Co. He is president of the Irish-American Engineers' Club and has been indorsed by that and other associations in his district. The example of this club in putting forward one of its members to do what has been refused them by other representatives might well be followed by other engineers' organizations.

Dexter Gate-Valve Reseater

The illustrations, Figs. 1 and 2, are of the Dexter machines for refacing gate-valve seats and their solid or split disks, without removing the valve from the pipe line.

Fig. 1 shows the machine applied to a gate valve. The adjustable cutter support is quickly adjusted to the valve and the rotary cutter centered with relation to the seat

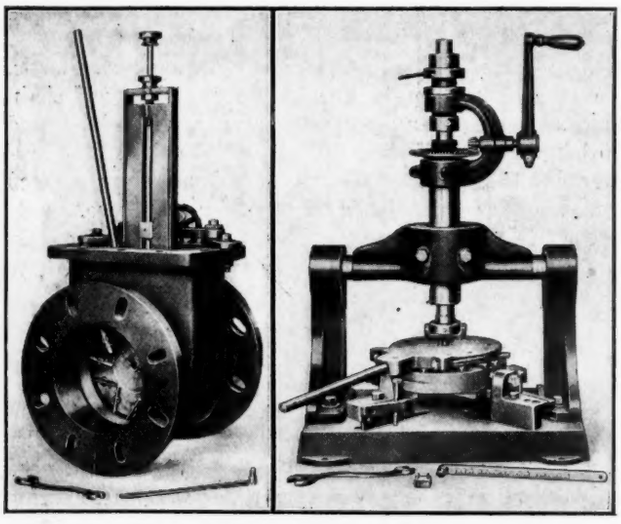


FIG. 1. REGRINDING A GATE VALVE

FIG. 2. REGRINDING A GATE-VALVE DISK

to be refaced. These adjustments are operated and controlled by the knurled nuts and feed wheels which are on the outside of the valve.

The adjustable cutter supports for centering and supporting the rotary cutters in the valve body are made in various sizes for valves ranging from 2 to 14 in. The wide angle of adjustment of the yoke on the lower end of the adjustable cutter bar admits of the machine being adjusted for proper operation on valve seats of widely varying distances apart and also at widely varying angles with respect to each other, from valves with parallel seats to those with varying angles. In all positions the adjustable cutter support and rotary cutter are kept close to parallelism with the valve seats that are being faced and, therefore, the axis of the ball-bearing stud on which the cutter rotates is kept as near normal as possible. A few rotations of the cutter, which is operated by the ratchet handle, is sufficient to reface the valve seat.

Fig. 2 shows the method of refacing a gate-valve disk, which is quickly leveled by turning the screw standards or dogs and securely chucked by turning the chuck screw on the end of one of the dogs. A few rotations of the cutter, operated by the ratchet handle, refaces the disk, and is given a finish by turning the crank handle while feeding lightly. This machine is manufactured by the Leavitt Machine Co., Orange, Mass.

Receivers or Pockets of ample size to contain any rush of water likely to occur should be placed in the line at drainage points. Tees in the running line, with their center opening downward and fitted with a short capped pipe to which the drain line is attached, will be found satisfactory. Such a fitting should also always be placed in the line, beyond the last opening for steam supply, to take care of water carried along by the rush of steam toward the dead end of the line. Chemically pure water, such as condensed steam, will attack wrought iron or steel vigorously when cooling, drain pipes, therefore, should be well covered to avoid such cooling and consequent corrosion.

Making a Van Stone Joint Under Difficulties

Ordinarily the installation of automatic nonreturn valves and work of a similar nature merits no particular attention, but the case herewith described is somewhat unusual and warrants mention of the methods used.

The valves between the main header and the boilers were of the ordinary angle type, but later automatic nonreturn valves were decided upon.

Referring to Figs. 1 and 2, *A* and *B* indicate valves of the original installation, being connected to the main header *L*. The two 6-in. boiler connections *E* and *F* are long radius bends, each having an offset bend at right angles to the long radius bend, of approximately 4 in. from the center line of valves *A* and *B*.

The nonreturn valves were to go directly beneath the angle valves, so the connections were blocked in position, the joint at *C* and *D* broken, and the pipe sawed off the right length for making a Van Stone joint.

The flanges were placed over the ends of the pipes, and 1¼-in. pipes cut to the exact length of the nonreturn valve. These pipes were bolted through flanges *C* and *G* and *D* and *H*, holding them the correct distance apart for the new valves.

A seal, as shown in Fig. 3 at *X*, was made of an old flange, turned ⅛ in. smaller than the inside diameter of the pipe, and provided with two setscrews, and also with a hole in the center for a ⅜-in. air nozzle, 12 in. in length, held in position by a collar and setscrews, closed at one end and perforated with a number of $\frac{1}{16}$-in. holes for air blast. To the end of this nozzle was connected an air hose let into the interior of the steam pipe through a hole provided by the removal of the nozzle plug of the steam flow meter.

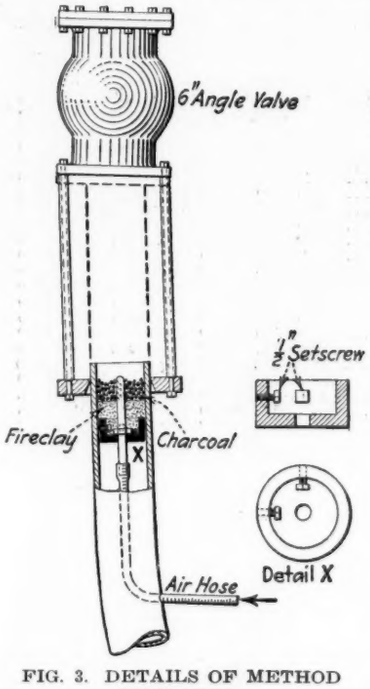


FIG. 3. DETAILS OF METHOD EMPLOYED

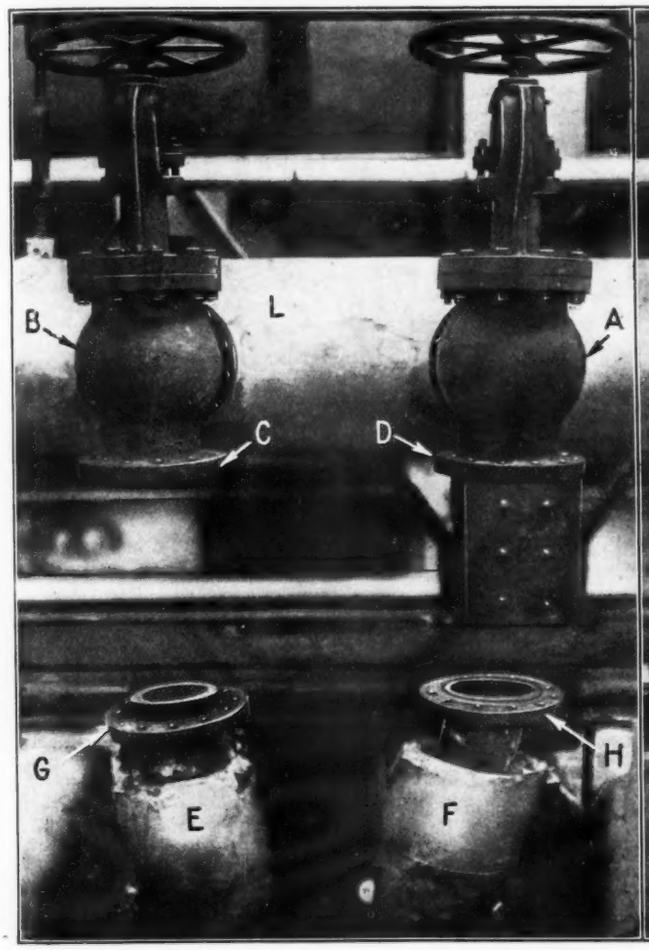
After the flanges *G* and *H* were bolted in their true position, parallel in all directions with flanges *C* and *D*, the seal with the air nozzle was introduced into the pipe and fastened in position, after which a bed of fireclay was placed on top of the seal, allowing the air nozzle to project, as indicated by the illustration.

A fire of shavings and charcoal was then started on top of the fireclay and by means of the air blast the heat was directed against the point where the lip was to be bent over. The air supply was adjusted to furnish sufficient heat without burning the pipe, to enable the projecting end above flange *G* and *H* to be peened into shape to form a right-angle turn which must be flat and true to make the joint on later.

A plate was used to deflect the heat downward to the end of the pipe. As soon as the lip was approximately in position, a sheet of glass coated with red lead was used to locate irregularities, which were removed by further peening, until the joint tested true all around.

The joint was made in a steam connection having a curvature in two directions at the point where the flange joint was made, and the work was accomplished with the pipe in its proper position. That the joints are now operating under 175-lb. pressure and 100 deg. superheat speaks very well for the skill and care exercised. The work was performed by the plant employees.

In Fig. 2 is shown the nonreturn valve installed and under working pressure.



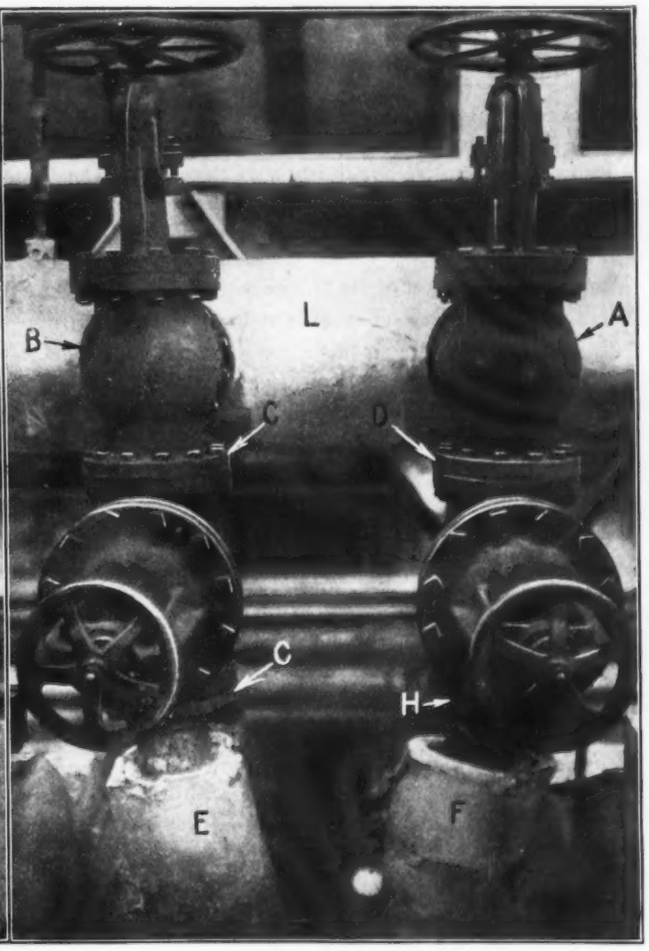


FIG. 1. SHOWING THE PIPES CUT AND WORK PARTLY DONE. FIG. 2. THE VALVES IN PLACE

Factor of Safety in Compulsory Boiler Inspection Laws

The factor of safety employed in engineering construction is made to vary not only with the character of the material used, but also with the nature of the loading to which the structure is subjected. The greater the variation in the strength of different test specimens of the material, the higher is the factor of safety employed for that material. Thus, for a homogeneous and ductile material, such as mild steel, a factor of safety of five might be employed, while for a material lacking in homogeneity and in ductility and for test specimens which show wide variations in strength, such as cast iron, a factor of safety of 10 might be employed. Again, for a structure such as a railroad bridge subjected to live loads varying between wide limits—that is, from no load, excepting the dead load, to maximum load—a factor of safety of five might be employed; whereas in the case of a roof truss not subject to a live load, a factor of safety of three might be employed.

For an engineering structure built in the form of a boiler and carrying extreme pressures, a factor of safety of five is not too great. It should be remembered that the term "factor of safety" is composed of two parts—one part a true factor of safety, the other a real factor of ignorance. The factor of ignorance takes care of differences in strength that often occur in the same piece of material, takes care of necessary abuse of the material while it is being punched and worked to form, and takes care of varying qualities of workmanship. The true factor of safety is, therefore, all that is left to take care of any overload to which the boiler may be accidentally subjected in service. Moreover, this particular factor is based upon the ultimate strength of the material, whereas the yield point of such material is only about one-half the ultimate strength. Consequently this true factor of safety is cut in half. For example, if the assumed factor of safety were five, and the factor of ignorance happened to be one, then the true factor of safety based on ultimate strength would be four, and the factor of safety based on yield point would be only two.

It is inconsistent to use a lower factor of safety for old boilers than for new boilers. Boilers in service are subjected to serious intermittent stresses due to expansion and contraction brought about by an alternate heating and cooling. Then, too, there is sometimes a breathing action in rhythm with the steam admission to the engine supplied by the boiler; and these various intermittent stresses gradually fatigue the metal and make it prudent to increase the factor of safety with age rather than to decrease it.

As a matter of fact, however, many boilers in service have a theoretical factor of safety of only four or even less. Although a factor of safety of five is desirable and is adopted in virtually all compulsory boiler inspection laws for new construction, it is usual to permit a factor of safety of 4½ on boilers in service at the time of the enactment of the law. This is probably the best that can be done, and it means, of course, that eventually the desired factor of safety of five will be attained.—"Monthly Bulletin," Fidelity & Casualty Co.

Causes and Prevention of Clinker

By L. Rankin

SYNOPSIS—The clinker problem is considered one of the most serious in boiler practice because it is so difficult to prevent clinker formation. The article treats of the various causes of clinker and tells how to prevent it. It is not an article full of chemical symbols, but everything suggested is capable of being applied by the fireman. The article was suggested by Bureau of Mines Bulletin No. 80.

Clinker is fused ash. Any coal will form clinker if the ash is heated to the melting temperature which depends on the chemical composition of the ash and on the conditions of heating. The effect of each constituent on the melting point of ash is not yet known, but it is certain that the nature of the atmosphere in which the ash is heated has a marked effect on the melting point. If ash be heated in an oxidizing atmosphere (an atmosphere that supplies oxygen) its melting point is higher than if heated in a reducing atmosphere (an atmosphere that removes oxygen) such as hydrogen or carbon monoxide. The difference between the melting points in an oxidizing and in a reducing atmosphere is for some coals over 261 F.

Effect of Thick Fire

The most common causes of clinkering are thick fire, excessive stirring of fires, burning coal in the ashpit, much slack in the coal, closed ashpit door, and preheating the air admitted under the grate. The ash of some coals is so fusible that it is difficult to burn without heating the ashes to their fusion temperature. However, with most of the coals mined in the United States troublesome clinker can be avoided by proper care of the fire.

Thick fires perhaps cause troublesome clinker as often as all other causes combined. Clinker forms in thick fuel beds because the smaller air supply through the grate permits the ash to become heated and because the heating is partly done in a reducing atmosphere of CO.

It is well-known that a thick fuel bed offers more resistance than a thin one to the flow of gases; therefore less air flows through the thick fuel bed. The air flowing from the ashpit through the fuel bed absorbs heat from the grate and the ashes above it and thus keeps them cool. If, by thickening the fire, the flow of air is reduced, the grate and the ashes on it are not cooled as much and the ash may become heated to its fusion temperature.

That a thick fuel bed lessens the cooling effect of the air flowing through the grate may be made clearer by the following illustration:

Suppose that in two boilers, A and B, similar in design and size, coal is burned at the same rate, the total air supply being 17 lb. per lb. of carbon in the coal. But in boiler A the fuel bed is 5 in. thick and in boiler B, 10 in. thick. The low resistance of the 5-in. fuel bed in A permits about 12.2 lb. of the 17 lb. of air used to burn one pound of carbon to enter through the grate, and only 4.8 lb. is admitted over the fuel bed. On the other hand the resistance of the 10-in. fuel bed in B allows only 7.9 lb. to enter through the grate, so that 9.1 lb. must be introduced over the fuel bed.

The composition at the end of the combustion space after all of the 17 lb. has been introduced and the combustion is completed is about as follows: CO_2, 14.0 per cent.; O_2, 6 per cent.; CO, 0 per cent.; N_2, 80 per cent.

It is plain that the 12.2 lb. of air flowing through the grate of boiler A absorb more heat from the ashes and thus keeps them cooler than the 7.9 lb. flowing through the grate of boiler B. Consequently the ashes in boiler B will become hotter than those in A, and the probability of bad clinker formation will be greater.

The fusion temperature of the ash is lowered by the reducing atmosphere surrounding the upper layer of ashes.

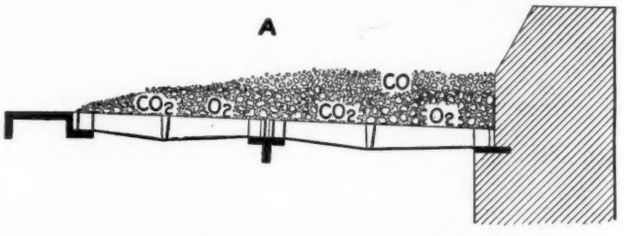


FIG. 1. GAS CONDITION WITH THIN FIRE

In a thick fuel bed the ash becomes mixed with burning coal to a greater height than in a thin one, and at the same time, on account of the lower velocity of the gases, the reducing zone is nearer the grate than in a thin fuel bed. In fact, in thin fires the reducing zone may be limited to the top inch or two of the fuel bed where the bits of ash are comparatively few and far apart and cannot fuse even if they are heated to the fusion point. The distribution of ash and the probable oxidizing and reducing zones are illustrated in A and B, Fig. 1. The reducing zone is marked CO; the oxidizing zone CO_2 and O_2. The line between the ashes and the burning coal is more marked in the thin fire than in the thick one.

Thick Fires Formed Clinkers

Two cases of clinker caused by a thick fuel bed are given herewith: At a plant containing two 250-hp. boilers, complaint was made of one or two shutdowns on account of clinkers. Investigation of the cause showed that at about 9 a.m. the fires were 12 to 16 in. thick and badly clinkered, and that the steam pressure was slowly dropping. The fireman stated that he had started the day watch with a clean fire at about 5:30 a.m., and that the clinker had accumulated since then. It was evident that the fire could not be run until noon, and a shutdown was inevitable, consequently firing was stopped altogether. The fires were allowed to burn down as much as possible and then thoroughly cleaned. Cleaning was difficult, as the clinker adhered to the grate, side and bridge walls. It took over an hour to clean the two furnaces. After cleaning, fires about 5 in. thick were carried and the steam pressure was kept easily near the blowing-off point until 9 p.m. without further cleaning. At this time the fires were cleaned. The refuse found on the grate consisted mostly of free pieces of ashes and was easily removed with a hoe. No slice bar was used. The plant could run easily from morning until evening without the fires being cleaned.

At another small plant having two horizontal tubular boilers of 150 hp. each, trouble from clinker was reported. A black substance was said to run in the grate and choke the air supply. On visiting the plant it was found that the fireman carried a heavy fire, 14 to 18 in. thick. The fuel bed extended to the fire-door, covering the dead plate and nearly filling the firing-door opening. The fire-door arches and lining were badly burned, and the cast-iron furnace front was cracked and warped in many places. The molten ash was running through the grate as a black, sticky substance, which hardened below the grate and formed "icicles."

The cleaning of this fire was difficult on account of the clinker being fused into the grate. After the fires were cleaned a light fuel bed about 5 in. thick was carried, and to the surprise of the fireman the load was carried with one boiler. After carrying a light fuel bed for six or seven hours the fires could be cleaned without the use of a slice bar. After the change to light fuel bed this plant had no trouble from clinker.

Disturbing Fuel Bed Causes Trouble

Next to a too thick fuel bed, excessive stirring of the fuel is perhaps the most frequent cause of troublesome clinker, especially if the fire is broken with a slice bar. Most soft coals will fuse in the furnace into a hard crust if fired in heavy charges, as practiced by many firemen. To break this crust some firemen run a slice bar under the fuel bed and pry up the crust by putting their weight on the handle. In this way they lift into the burning coal the ashes and small pieces of clinker, which soon fuse into sticky clinker. The ash fuses because of the high temperature and the reducing gases in the upper layer of the fuel bed. Even leveling the fuel bed with a rake causes clinker if the rake is handled carelessly and the ash is lifted to the surface of the fuel bed.

Burning coal in the ashpit is often the cause of sticky clinker. Usually, such coal is shaken through the grate in the leveling of thin fires. Allowing holes in the fuel bed to burn out and attempting to cover them with fresh fine coal is another cause of burning coal in the ashpit. Unless the ashpit contains water a fire is started there hot enough to heat and to melt the ash above the grate. The molten ash runs into the grate and, by stopping the

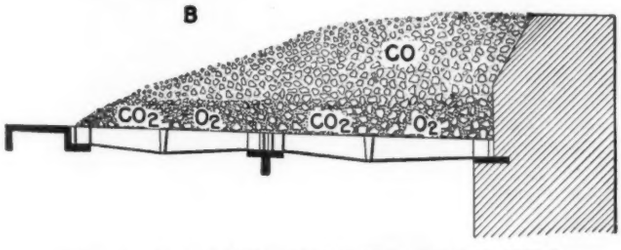


FIG. 2. GAS CONDITION WITH HEAVY FIRE

air spaces, shuts off the air supply, thus making conditions worse. The grate bars may become so heated that they soften and gradually warp, so not only are shutdowns caused but the grate bars are destroyed. Because of clinker filling the air spaces in the grate the cleaning of such fires is slow and difficult. The clinker seems to corrode or combine with the grate bars.

The following case is typical of bad clinker being caused by burning coal in the ashpit: At a plant having three horizontal-tubular boilers serious trouble from clinker was reported and, as usual, the blame was put on the coal. When the plant was examined it was found that the fires were in fairly good condition except, perhaps, that on the rear of the grate they were too thin. There was, however, considerable burning coal in the ashpit. It was noticed that the fireman placed most of the coal on the front part of the grate, at times even leaving part of the grate in the rear uncovered. A few minutes after each firing he took his rake and pushed the burning coal from the front of the grate to the rear, which was partly bare. While the coal was being pushed back some of it fell through the grate, so that a hot fire was kept burning under the grate, heating it and causing the ash to melt into sticky clinker.

These grate bars were of the herringbone type with air space originally about one-half inch wide. They showed signs of considerable overheating; the middle of each bar was sagged three to four inches. Most of the air spaces were filled with clinker, which seemed to be combined with the iron of the grate.

The fireman was instructed to pull the fire out of the ashpit and fill the latter with water. Furthermore he was told to place the coal when firing where it was needed and avoid using the rake. These measures were effective—the clinker trouble was stopped, and the loss of coal in the ashes reduced.

Coal containing much slack is sometimes an indirect cause of clinker. Slack coal tends to form a hard crust at the surface of the fuel bed, particularly if the charges are heavy. In the breaking of this crust the ash is mixed with the hot burning coal and is melted.

Closing the ashpit door stops the flow of cooling air through the grate and the ash on it, thus permitting the ash to become heated and to melt into troublesome clinker.

If the air supplied to the ashpit is highly preheated, it will not, of course, cool the ash on the grate, and the ash in consequence may become heated and melt. At few boiler plants is the air preheated, so that this cause is rare. However, in gas producers using economizers the preheating of the air is a frequent cause of trouble from clinkers when coals having ash of low fusion temperature are used.

How to Avoid Clinker

The following are some general suggestions for avoiding clinker troubles:

Use thin fires and keep the fuel bed level by placing the fresh coal on the thin spots. Avoid leveling the fuel bed with tools. Above all, do not disturb the fuel bed with a slice bar.

Fire coal in small charges, thus reducing greatly the formation of a crust on the surface of the fires and the need of breaking this crust. Be careful to use small charges if the coal contains much slack.

Avoid burning coal in the ashpit. If the ashpit is water-tight, keep water in it; if it is not, then blow steam under the grate. The steam can be taken from the exhaust of a feed pump or from any other supply of waste steam. In passing through the ash on the grate and through the fuel bed, the steam is superheated and then partly decomposed into oxygen and hydrogen. The heating and the decomposition of the steam absorb heat. It is thought that this absorption of heat keeps the temperature of the ash below the melting point.

Keep the ashpit door open. To regulate the draft use the damper in the breeching.

If all of the foreging rules are observed, under ordinary circumstances and with coal of the average quality there will be no trouble from clinker. In case clinkering continues relief can be had by spreading a few shovelfuls of crushed limestone over the grate when starting from a banked fire or after cleaning. The limestone should be broken to the size of a walnut.

To fire by hand soft coals containing much slack is harder than to fire coarse coal and requires much more care and skill on the part of the fireman. The chief difficulty in burning slack is its tendency to cake; that is, to fuse and form a hard, tight crust. Little air flows through the fuel bed and little coal burns except where the crust cracks. Under such conditions the rate of combustion is low and the boiler is run below its rated capacity. The heavier the firings, the thicker is the crust and the fewer are the cracks where it burns. To make the coal burn, the crust must be broken so that air will pass through the fuel bed.

This caking of slack coal has a good result—it keeps a large part of the fine coal from being wasted in the ashpit. Slack coals that do not cake, such as lignites, sift into the ashpit whenever the fuel bed is disturbed.

Some men fire "slacky" coal in heavy charges, 300 to 500 lb. at a time, and break the crust that forms by running a slice bar under the fuel bed and prying the large masses of caked fuel to pieces. The coal then burns rapidly and makes a very hot fire. The firemen's idea is to fuse the fine coal into a solid mass and then to break this mass into lumps of suitable size for rapid combustion. Thus they actually first make the slack coal into lumps, and then burn these in the usual way. A slice bar must be used because the mass of the caked fuel is too large to be broken with a rake. The latter is sometimes used to break the smaller piece and to level the fuel bed after the large masses have been broken with a slice bar. In firing a slacky coal the method just described seems to work well if the coal has an infusible ash.

Coals having fusible ash clinker badly with such treatment, and a better method of firing them is to keep the fuel bed about five inches thick and fire small charges of coal at frequent intervals. The crust that forms on small charges is thin and burns through in two or three minutes. It can be broken if need be, with the prongs of the rake. It is better to break only the crust at the surface of the fire and not to disturb the fuel near the ashes, so that the ashes will not be lifted into the hot zone of the fire, where they may melt.

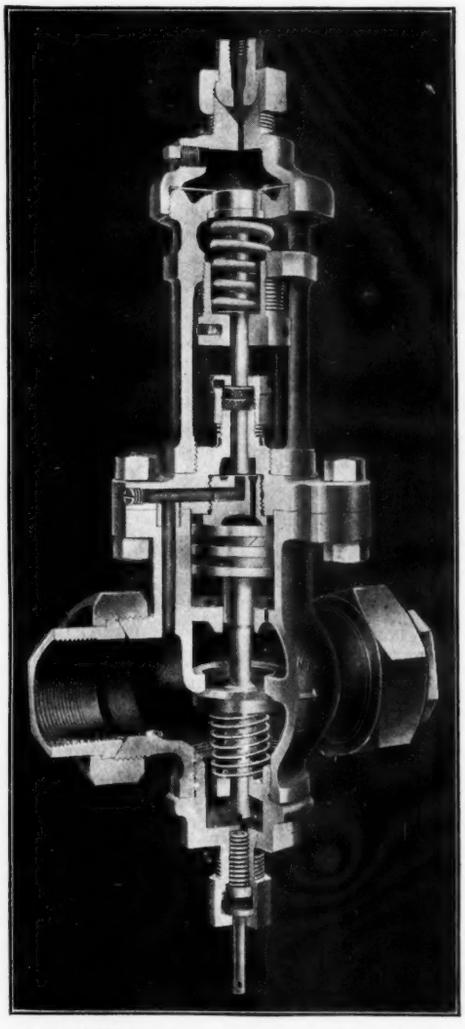
If the firing is light and is skillfully done, the rake need not be used often—perhaps only every fourth or fifth firing. If too much free ash accumulates on the grate a small hook can be run under the fuel bed, care being taken to keep the hook always flat against the grate. The ashes will be shaken through the grate, and only a few pieces will be lifted into the hot zone of the fire. The hook is of little use if the ashes have fused into large pieces of clinker.

A strong draft is needed to burn slack. At plants where the draft is weak larger sizes of coal should be burned. Of course when the size of coal is radically changed it must be remembered that the draft must be readjusted because the resistance of the fuel bed will have been changed.

Atlas Regulating Valve

The Atlas regulating valve, illustrated herewith, is manufactured by the Atlas Valve Co., Inc., 39 Cortlandt St., New York City. It is of the type known as auxiliary operated, the opening of the main valve being controlled by an auxiliary valve. Normally the main valve is held closed by a spring of sufficient strength to overcome the weight of the main valve. The auxiliary valve is always open until closed by pressure acting on the diaphragm overcoming the power of the adjusting spring.

When steam is admitted to the valve it passes through the port on the inlet side of the regulator into the auxiliary valve chamber and then to the top of the controlling



SEMISECTIONAL VIEW OF THE ATLAS REGULATING VALVE

piston, which, being of larger area than the main valve, forces the latter open and permits steam to pass to the outlet, or low-pressure side of the regulator.

This valve is designed for as high as 250 lb. pressure, including ½- to 6-in. size. For superheated steam it is furnished with a steel body and removable seat. It is for all classes of service. When used for controlling the speed of a boiler-feed pump a special top is used to guard against pump pulsations and to prevent hammering on the diaphragm. Used as a pump governor the device has a limit screw to control the speed of the pump and prevent racing.

Stocker Cooling Towers

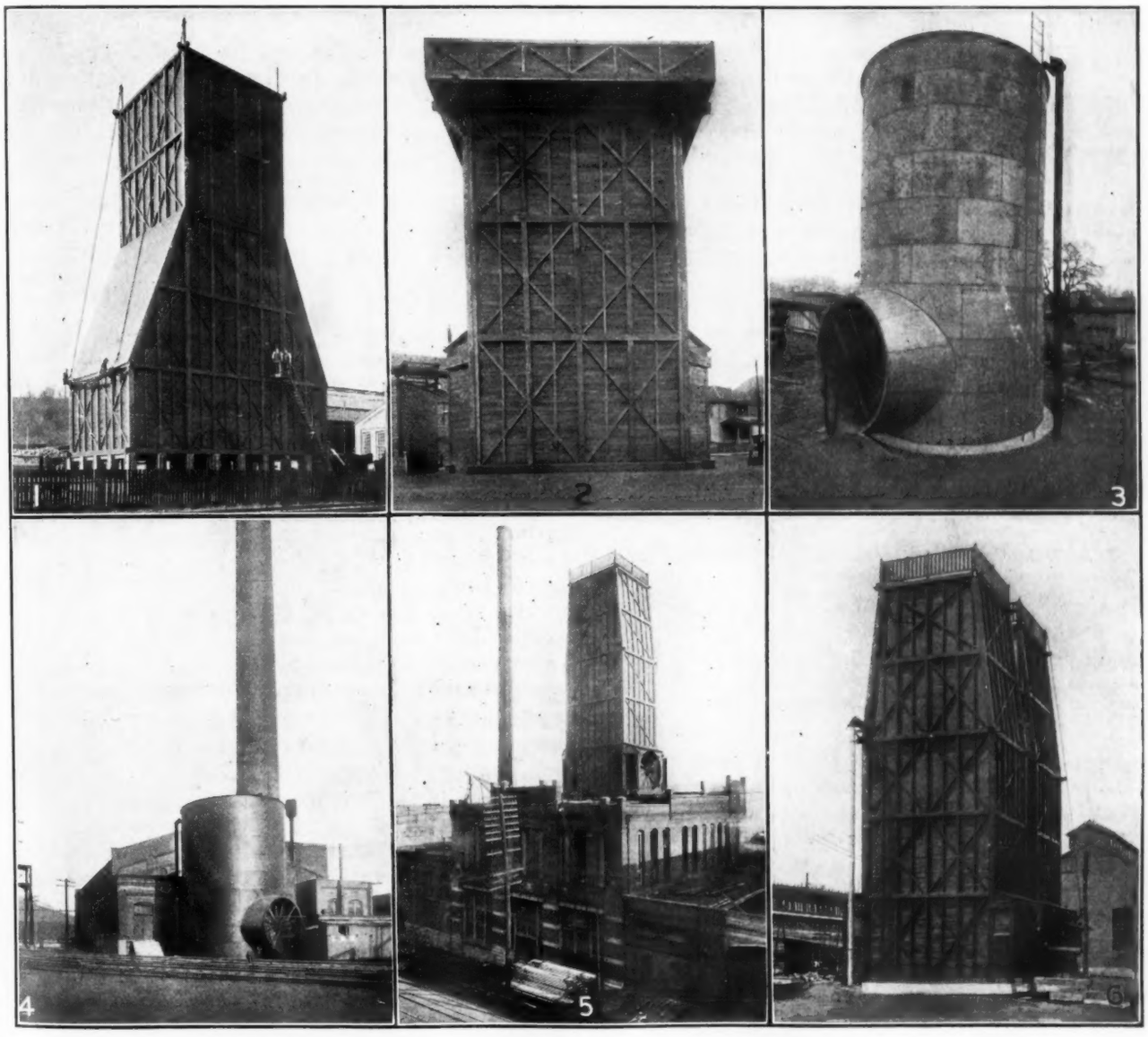
The durability of cooling towers depends primarily on the construction and, secondly, on the material used. For the cooling or wet surfaces, as well as for the lining or sheathing—that is, for all parts of the Stocker tower exposed to water and vapors—Louisiana swamp cypress is used exclusively. The outside frame of the tower is built either of wood impregnated with a wood-preserving paint or with a shell of steel or galvanized steel covered with metallic paint.

The construction of the filling and water distributing device is as follows: The filling is composed of checker work or cross-pieces of boards in horizontal layers, diagonally intersected in each square or checker by uprights (vertical boards) extending through the length of the filling. By this construction the boards are mutually and rigidly braced at short intervals, and warping and bending of the wet surfaces, deflecting water and air from their intended course, is prevented.

The support for the filling is independent of the outside frame or shell of the tower. This feature consists of a free space of from 3 to 5 in. between the filling and the shell, which, if filled with concrete or any other insulating material, will prevent the corrosion of the shell from the inside.

The water to be cooled is first pumped into two or three large troughs, depending on the size of the tower; from there it flows through open gutters into smaller troughs, which in turn empty the water through V-shaped notches directly on to the top edges of the cooling boards. No splashing occurs, nor can any section of the filling receive more or less than its apportioned share, whether the load is heavy or light. With varying load the volume and not the velocity or spray area of the water is changed.

Impure water may be circulated without detriment to the working of the apparatus or greater inconvenience than a more frequent cleaning of the troughs, which, without stopping operation, can easily be done with a hose



FIGS. 1 TO 6. SEVERAL TYPES OF STOCKER COOLING TOWERS

Fig. 1—Natural-draft tower, wood construction. Fig. 2—Forced-draft tower, wood construction. Figs. 3 and 4—Forced-draft towers, galvanized steel and steel shell, respectively. Fig. 5—Combination tower, forced draft with chimney. Fig. 6—Combination twin towers

or broom. The troughs can also be readily removed from their sockets.

The three types of cooling towers manufactured by George J. Stocker, 2833 S. Kingshighway Boulevard, St. Louis, Mo., are: Standard forced-draft towers; combination forced-draft towers with chimney extension, and natural-draft towers, which, in their main construction, the filling and water distribution, are alike. Each has its specific field of usefulness, according to atmospheric conditions, available space, price of fuel, water, rates, load conditions, etc. These types are illustrated in Figs. 1 to 6, and although not new on the market are not well known to some of our readers.

Of the forced-draft type the standard tower is cheaper in first cost and lighter in weight than the combination tower, but the operating expenses of the latter are about one-third less on account of the draft generated in the chimney, which reduces the air pressure (water gage) about 25 per cent., making it possible to run the tower without the fans or at reduced speed during dry and cold weather.

The lowest operating expenses are obtained with a natural-draft tower, which in a general way deserves the preference where the average summer temperature does not exceed from 70 to 80 deg. F. The first cost of this tower is about the same as of the combination tower; the floor space, however, is approximately twice as large.

Steam Pipes

To find the weight per minute of steam flowing in pipes (Babcock's Rule):

$$W = 300\,\frac{D\,(P-p)\,d^5}{L\,(1+\frac{3.6}{d})}$$

in which

W = Weight of steam in pounds;
d = Diameter of pipe in inches;
D = Density or weight per cubic foot of steam in pounds;
P = Initial pressure in pounds per square inch,
p = Pressure at end of pipe in pounds per square inch;
L = Length of pipe in feet.

The loss of head due to generation of the velocity of flow and the friction of steam entering the pipe is about equal to the resistance of a length of pipe equal to the quotient of 114 diameters, divided by $(1+\frac{3.6}{d})$, in which d = the diameter of pipe in inches.

To find the diameter of steam pipe for a given size cylinder the formula is

$$D_1 = \sqrt{\frac{D^2 \times P}{8000}}$$

in which

D_1 = Diameter of steam pipe in inches;
D = Diameter of steam cylinder;
P = Piston speed in feet per minute.

Loss due to condensation in long steam pipes was shown by tests carried out by Henry Davey on a 7½-in. diameter steam pipe, 1 in. thick and 1100 ft. long, conveying steam at a pressure of 45 lb. per sq.in. to an underground pumping engine in the Morton pit at Clay Cross, the pipes being covered with a nonconducting material. As the result of careful observation it was found that the condensation of steam in the pipe amounted to 500 lb. per hr. when the engine was standing, and 750 lb. per hr. when the engine was working, equivalent to 0.183 and 0.274 lb. per sq.ft. of surface of pipe per hour, respectively.

In another experiment, carried out by W. W. Beaumont at the Staveley Hill colliery, it was found that in a total length of 2300 ft., 1900 ft. of which was underground and covered in some instances to a depth of 2 ft. with rough stuff left after cutting away the coal, the condensation in a 6½-in. pipe, 1⅛ in. thick, conveying steam at an average pressure of 34 lb. per sq.in., was 600 lb. per hr. with the engine standing and 1400 lb. per hr. with the engine at work, equivalent, respectively, to a condensation of 0.113 and 0.265 lb. per sq.ft. of surface of pipe per hour.

JUST FOR FUN

More Such Candidates Should Be Rejected

In a certain New England town which owns and operates its electric-light plant, a certain citizen was running for the office of commissioner of public works. He dropped into the plant one night and began a searching examination of the things he would have to oversee in his future position. Above all things he was perplexed that, though the load was light the plant continued to run after 1 a.m. "Why can't you pump a lot of juice into the wires during the evening and then shut down until 6 a.m. and save all that coal?" he kept asking. He was assured that "probably no one ever thought of that." He made this one of the strong points of his campaign, but, strangely enough, was not elected.—William E. Dixon, Cambridge, Mass.

A Couple of "Bone-Head Stunts"

Sammy was set to work putting up two channel-irons from one ceiling timber to another to support a new countershaft. He put up a staging and got one channel-iron up all right, but had difficulty in holding the other to get the lagscrews in.

He placed his head between the two, holding the iron up with his shoulder. When the last lagscrew was about three-fourths of the way in, the wrench slipped from his hand to the floor. He started to get it, only to find that he was caught fast by the head, as the two channel-irons were only 5 or 6 inches apart. He yelled for help, but when the boys saw how he had trapped himself they let him stay for a few minutes—just for fun.

Our wireman got a hurry call to wire up a ¼-hp. motor before quitting time. He mounted a step ladder and connected two wires to an overhead lighting line, then hurried to the floor, caught up one wire, removed the insulation from about one inch of the end and held it between his teeth while he stripped the other wire. The moment his knife cut through the insulation and touched the wire he began to spit fire—but not for fun.—O. M. Dow, Lowell, Mass.

Jokes on the Boss

One morning while in an animated argument with the boss, who was standing right next to the high-pressure engine cylinder, and just at the climax of the boss's remarks, one of the cylinder-relief valves popped in close proximity to the seat of his trousers. His right-about-face was wonderful, and he had just spotted the offending valve when the other one popped just behind him; then he made a hasty exit.

The factory handled a class of very inflammable material and the boss was very particular about fire protection, and was in the habit of inspecting at odd times. One day, on returning from a long absence, he found some of the firebuckets, which were hung at arm's length above a man's head, empty. He immediately went in search of the factory manager and myself, gave us the very devil and took us to see the buckets. On arriving at the empty (?) bucket he reached up and, grabbing it by the rim, tipped it over. To his surprise a brimful bucket dumped its contents over his nice new suit. It happened that one of the foremen had seen the first inspection and ordered the buckets filled.—Aug. Ulmann, Jr., Matanzas, Cuba.

Editorials

Stripping Problems of Their Nonessentials

Ability to go to the heart of an engineering problem and for the time being to discard all merely incidental factors is a valuable characteristic of the expert. Skill in this direction is worth much to an operating man whose advice is sought by a busy superior, and often leads to advancement. The qualification of being able to go straight to the mark in attacking points requiring technical consideration can be cultivated as long as an engineer is in service, and in no small degree it resolves itself into a sense of proportion which grows with experience and helps solve many difficult questions during one's professional career.

Take the selection of fuel for a given boiler installation. Probably no branch of steam engineering concerns itself with so many variables as does combustion, and the capacity to pick out essential points in dealing with such a question calls for real insight. Calorific power, chemical constituents, adaptability to hand-fired grates or to mechanical stokers, air pressures necessary for smokeless combustion, yield of ash, cost and other factors enter the case. More than a superficial knowledge of the fitness of coal of different kinds for a given service is demanded, and this means familiarity with the limitations of different grades of fuel for particular combinations of men and equipment.

In one installation, for example, local storage facilities may be such that the ventilation of the fuel is inadequate, and hence a coal with a lower volatile content must be selected even at the sacrifice of some heating value. A large percentage of oxygen in the fuel indicates liability to spontaneous combustion, for the oxygen content is an index of the avidity with which the fuel absorbs oxygen from the air. Prompt recognition of the controlling factor in selection is essential. In the purchase of coal for another plant, equipped with mechanical stokers and ample furnace volumes, high volatile content offers little difficulty, compared with its inferiority for service in a boiler plant where the combustion space is restricted, with hand-firing and forced draft necessary for the production of full power. Coals high in volatile matter can be burned efficiently where natural draft and mechanical stokers giving a slow rate of heating are used in connection with boilers having ample combustion spaces. In the selection of coal for naval service, fuel with a high volatile content is not desirable, although it may be very high in heating value, and judged purely on the latter basis would be ranked high as fuel for any purpose. The ability to see what are the essentials of the problem of selection for a given case is thus one which enables its possessor to avoid acting upon general ideas, his choice being based in the last analysis upon the controlling factor or group of conditions.

Again, suppose that in the rehabilitation of a plant the question arises whether to install remote-controlled or hand-operated switches. The study of the case soon shows the experienced man that in some particular instance the space limitations in the operating room make a proper control of the enlarged station by a bench board necessary, even though the cost of the installation may be greater by several hundred dollars. In reaching this conclusion, the engineer competent to strip off the incidentals of the problem will not make the mistake of overlooking them, but he will see almost at a glance that they cannot really control the decision. Another time he may find that the cost of remote control is not warranted for the size of the station, which can easily be operated by one man per shift on the electrical side of the boiler room or forebay wall, or it may appear on investigation that the simplest possible equipment is the best for the class of men available, as in a plant in a district far from skilled labor and perhaps operated by relatively untrained "natives."

Nowhere does this kind of insight show to better advantage than in conferences with one's superior, and quick adaptability in grasping essential points is sure to be appreciated by a hard-pressed executive. In every walk of life the pursuit of the significant is the proper aim of the ambitious worker, and the engineer who cultivates this talent reaps a certain reward in increased personal efficiency, with all that that implies.

Hydro-Electric Power in Washington?

A big hydro-electric project under Government ownership and operation, for the double purpose of increasing the water supply and providing cheap electric current for public, commercial and domestic use in the national capital, may be seriously proposed to Congress in the near future. Such a project was the subject of a recent conference between the Secretary of War and the commissioners of the District of Columbia.

In this project it is planned to utilize the water-power potentialities of the Potomac River at Great Falls and in the rapids between the falls and the city of Washington. In fifteen miles here there is a fall of approximately one hundred feet in the river. Plans for utilizing this water power for hydro-electric development have been sporadically discussed for thirty years or more, and numerous surveys and investigations have been made, both by Government engineers and others. Just why no action has ever been taken toward utilizing this unused power and giving the national capital cheap power, light and heat is a mystery.

Senator Norris of Nebraska became interested in the possibilities of this development several years ago, and has been persistent in his efforts to attract attention to the subject, with a view to making an object-lesson of a great municipal hydro-electric plant in Washington.

Engineers have estimated at various times that the average potential horsepower in the Potomac above Washington is from forty to sixty thousand horsepower, with a maximum of one hundred thousand horsepower. To develop this power to its fullest extent, the plan generally

favored is to construct a large dam and auxiliary reservoir at a point about nine miles below Great Falls, which would serve to augment the city's water supply and at the same time furnish power for an electric plant to be located at the dam. An auxiliary steam plant now in operation in Washington and owned by the Government would be made a part of the project.

The plan being considered by the Secretary of War is to have the War Department build and maintain the dam and generating plant, as it now maintains the reservoirs and mains of the water system for the District of Columbia. Current produced by the plants would be delivered in the city for distribution under the supervision of the district commissioners. Under such a system the people of the city of Washington now have very cheap water rates, and it is believed by those who are fathering the municipal hydro-electric scheme that correspondingly cheap electric rates to consumers would be possible with the development of the Potomac project.

Importance of Conscience

The engineer who has never had a failure, accident, or some form of misfortune in the operation of his plant has not been operating long. Troubles are almost bound to come, and they are hard on the engineer with a tender conscience, who is likely to blame himself for them.

There are many things which help to cause accidents. First, materials vary. Two flywheels cast from the same pattern and poured from the same heat will invariably burst at different speeds; so the precise bursting speed cannot be computed. The engineer can do little more than "trust to luck" so far as the flywheel and strength of materials in general is concerned.

Second, the engineer does not design his own machinery, at least not often. Generally he is dependent on the engineer who "built the machine in his mind" and transferred it to paper. Improperly designed machinery has frequently caused terrible disasters.

Vibration, age, electric action, corrosion, heat and cold are other contributory causes, over which the engineer usually has little control. Most people give them no thought, but the engineer who feels his responsibility shudders each time the realization of the many dangers comes to his mind. He cannot help it, and it does no good to tell him to be more carefree.

This is just as it should be. We should all be conscientious, and most of us are. Otherwise there would be many more accidents. The designer is conscientious and appreciates his responsibility and the helplessness of the engineer should he fail in his computations. The builder is conscientious in the selection of proper materials. A factor of safety is employed, but that does not always prevent accidents. Hence it is aimed to use one that is large enough. The factor of safety is often dictated purely by conscience; sometimes, true enough, by laws.

The machinist also senses his responsibilities. Workmanship is of as great value in preventing accidents as materials and designs. When a machinist or machine erector errs, his conscience should trouble him, and it usually does.

Lastly, the engineer. He should be more conscientious than any of them. He should handle the machinery to the best of his ability. He should observe everything, understand everything pertaining to his work, and everlastingly bear all contributory causes in mind. It is hard on the constitution, but it is necessary to the best, continuous, accident-free service.

Should the Chief Engineer Hire His Subordinates?

The increasing amount of executive work falling upon the shoulders of engineers is significant. The days are rapidly passing when plant owners can regard their station chiefs as simply advanced mechanics with a detailed knowledge of steam and electrical machinery from the operative standpoint. Results are today more important than methods in the eyes of progressive managers, and the tendency is to place more and more responsibility upon the head of the plant, letting him select his own means of making good. Nothing is more important in this connection than giving the chief engineer full sway in the choice of subordinates.

In different companies the arrangements connected with employment naturally vary widely, but no matter what routine a man is obliged to go through before acceptance, it is only fair that the chief engineer be given the opportunity to pass upon the applicant after a personal interview with him, before handing him a locker key. Thoroughness in selecting employees is a feature of many corporations' working organizations today commanding much admiration, but no matter how good a showing a man may make in the superintendent's office, in the physician's laboratory and in the verbal or written tests which may accompany his efforts to join the staff, a new man should not be forced upon the "chief" without the latter's approval of his fitness for service. Every chief engineer needs to realize the importance of learning to "size up" men, as well as to "shoot trouble" within the machines under his control, and as the stations increase in size, the specialization of labor within their walls also multiplies, and the ability to surround oneself with an efficient staff becomes more and more important.

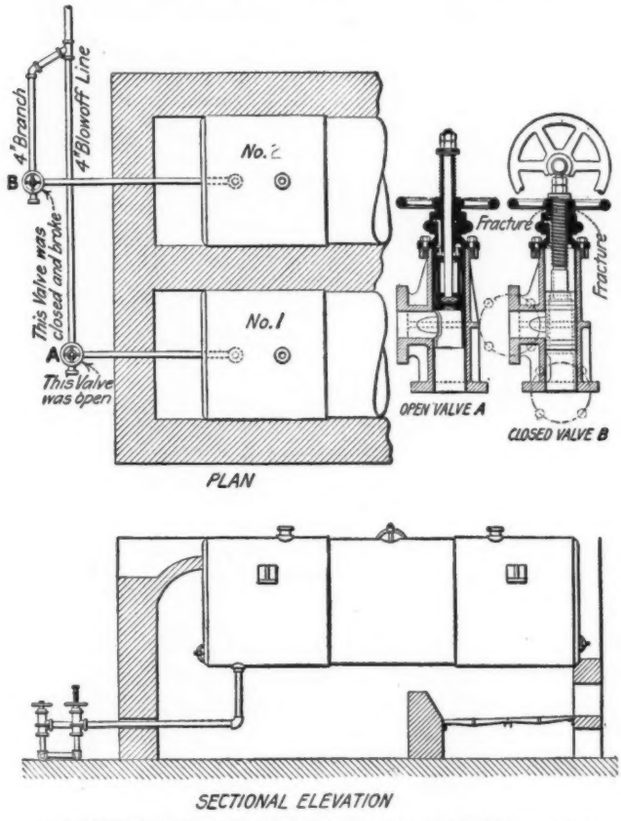
No employee of a welfare department or other branch of an organization working outside the plant can so appreciate the qualifications of the existing staff as can the superior immediately in charge, and it will be many a long day before station design becomes so cut and dried that individuality will not count heavily in the successful operation of power-generating equipment. No one knows so well what sort of a temperament will fit into a given part of the station service as does the chief engineer; in other words, the "chief" knows the personal equation of the staff as no outsider possibly can, and his judgement as to the suitability of a new man for his organization ought to be the best.

Capt. Thomas M. Rees, of Pittsburgh, is going before the Commission of Labor and Industry of Pennsylvania and demonstrate that no boiler ever blew up because of the lap-seam, and that the lever safety valve is safer and better than the pop. He took a round out of the code at the Erie meeting of the Boiler Manufacturers' Association. If the newspaper reporter caught him right, he also believes that cold-driven rivets are better than hot-driven. He has been accorded a hearing, to take place some time in September.

Correspondence

What Broke the Valve?

The illustration shows an arrangement of blowoff piping and connections which are thought to have been responsible for the rupture of a blowoff valve of a boiler in operation under 125-lb. pressure while blowing down



ARRANGEMENT OF BLOWOFF CONNECTIONS AND DETAILS OF BLOWOFF VALVES

another boiler whose blowoff was connected with the same blowoff line. Perhaps readers of *Power* can suggest why the valve which failed should have broken.

As indicated in the sketch, boiler No. 1 was connected near the dead end of a 4-in. blowoff line. The blowoff connection from boiler No. 2 was carried over the main blowoff line to the 2½-in. blowoff valve *B*, which was ruptured, the latter being connected by a short drop, 4-in. pipe and Y branch to the 4-in. blowoff main, which was extended over the boiler-room floor for a distance of about 100 ft. to its point of discharge and received the blowoff connections of ten additional boilers.

The fireman reported that while blowing down boiler No. 1 he heard a shock in the piping, and upon observing that the blowoff valve of No. 2 was ruptured, he immediately shut off the steam connections and drew the fires of the mechanical stoker of that boiler as hastily as possible, though not until it had been completely emptied and was somewhat injured from the high temperature of the furnace.

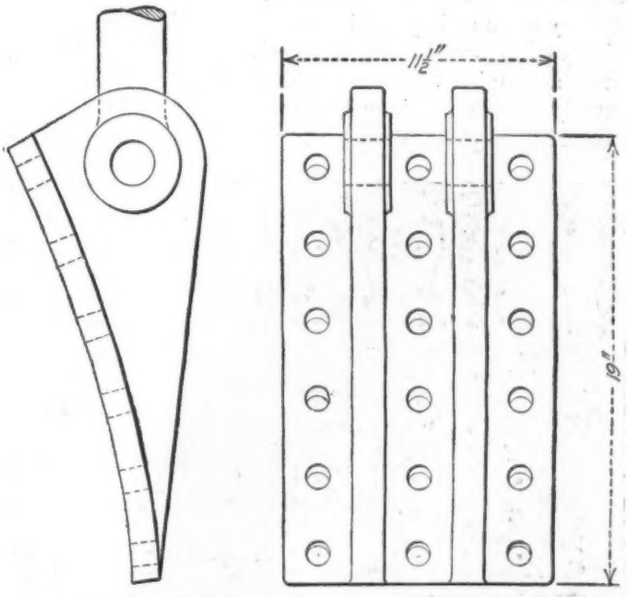
As indicated in the sectional view, the ruptured valve was of the piston type, and it was found that the rabbeted hand-wheel nut for holding the valve spindle had been broken, showing a sharp fracture. The location of the fracture is indicated in the detail. With the valve closed, such rupture would result from pressure or impact tending to raise the valve. Was failure of the valve due to arrangement of the blowoff connections, or what was it that broke the valve?

N. Olson.

Pittsburgh, Penn.

Supporting Horizontal-Return Tubular Boilers

The article by Prof. A. A. Adler in *Power* of July 27, p. 130, refers to my use of the Woolson 3-point suspension for horizontal-return tubular boilers (printed in the issue of June 22, p. 848) and gives a diagram of a bracket for supporting such boilers. From an examination of the diagram accompanying my article it will be seen that the form of bracket illustrated is longer than that shown by him, and that its shape and position are such that there is very little bending moment applied to the plates



BRACKET FOR SUSPENDING HORIZONTAL-RETURN-TUBULAR BOILER

of the boilers, and therefore very little tendency to bend them. The sketch herewith shows a larger diagram of the form of bracket that I have always used. It will be seen that provision is made for three rows of rivets, 18 in all. These have been used for 72-in., 84-in. and 90-in. boilers, and it will be observed that the direction of the link is about tangent to the shell of the boiler. I do not think that there is any need of placing a plate on the inside of the shell when a good bracket like this

is used. The brackets are made of steel castings, and are so stiff that they will not become distorted, and I do not believe that by their use strains of any consequence are produced in the shell, either from bending or otherwise.

F. W. Dean.

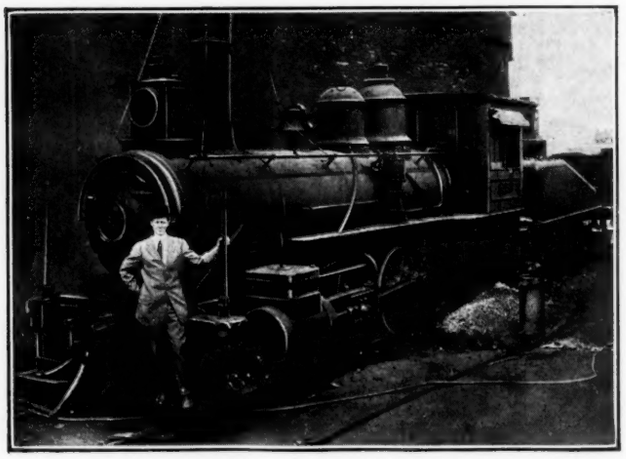
Boston, Mass.

Inefficient Railroad Power Plants

Having been for some time in railroad service, I have inspected a number of power plants operated by different roads at their division shops and roundhouses. The inefficient character of these plants cannot help but impress the engineer who has also had experience in the power houses of private concerns.

It is hard to introduce any new device into engineering work, even if its use would result in a considerable saving. This is particularly true where some other, more familiar, device may be employed. Mental inertia may be the cause of the large number of old locomotive-boilers in railroad plants. Such a boiler is poorly adapted to stationary work and uses an excessive amount of fuel. It is also more difficult to clean and keep in repair than is an ordinary horizontal tubular boiler. Of course most roads use boilers that are no longer strong enough for service on a locomotive, and thus save the first cost of the boiler. This might seem entirely justified in a temporary installation, but where, as usually happens, the outfit remains in service for a long period of years, the increased cost for fuel and repairs must more than offset the saving in the original outlay.

Very often a simple, slide-valve, throttling engine, running at low speed, is used to drive the shop machinery. Such an engine uses a great deal of steam at best, but usually no attempt is made to save even the heat in the exhaust. It goes up a pipe to the roof, and an injector



LOCOMOTIVE BOILER IN STATIONARY WORK

uses additional steam to feed the boiler. In such an installation many dollars might be saved in the course of a year by the use of a feed-water heater with a pump driven from the engine's cross-head, or with an ordinary power pump.

A typical inefficient railroad power plant is shown in the accompanying illustration. An old switch engine, its days of yardwork ended, has been run on a track next to the roundhouse and supplies steam to the engine driving the machine shop. An extension on the stack furnishes the necessary draft. The boiler radiates a great quantity of heat, and probably is so filled with scale inside that the amount of coal burned is twice that needed in a small stationary boiler. Yet the railroads are hard pressed financially, and such an outfit is supposed to be saving money. The majority of railroad power plants are sad examples of inefficiency.

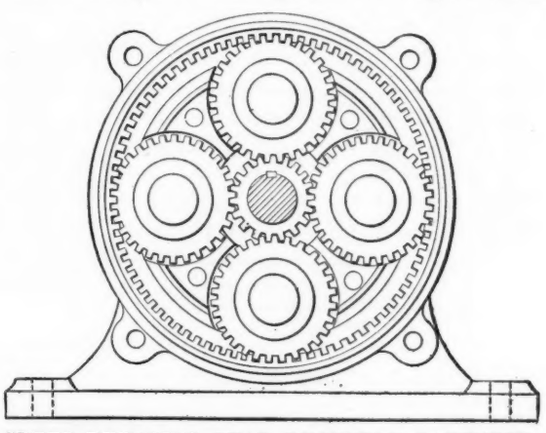
Hugh G. Boutell.

Washington, D. C.

Internally-Geared Speed-Reducing Mechanism

I notice in *Power* of June 29, p. 887, a description of a turbo-reduction gear made by the Turbo Gear Co., of Baltimore, Md.

I inclose a copy of letters patent for a speed-reducing



SPEED-REDUCING GEAR RECENTLY PATENTED

gear, issued to me on May 11 of this year, which appears to embody the same principle. I consider, however, that my arrangement is more simple and can be made as strong as desired.

John Neill.

Honolulu, T. H.

Exhaust Steam Regenerators

There appears in *Power,* Aug. 3, p. 143, an article entitled "500 Kw. from Exhaust of Hoisting Engine," the synopsis of which reads as follows:

"One of the few regenerator and mixed pressure turbine plants using successfully the exhaust from a hoisting engine."

We believe that this is quite unfair, and certainly incorrect. There are several hundred plants using steam regenerators in conjunction with hoisting engines, and I have not heard that any of the plants we have placed in operation could be called unsuccessful; quite to the contrary, all of the plants have proved themselves very economical.

We are now the only manufacturers of steam regenerators in this country, and have installed a large number of regenerator plants, and are at present installing several more.

Rateau Steam Regenerator Co.,
L. Battu.

New York, N. Y.

Concrete Switchboard

In a mill where I was employed there is a 500-volt, direct-current motor driving the machine shop. The switch, fuse blocks and rheostat were fastened to the wall of the building with sheet asbestos for protection.

One day the insurance inspector came in and insisted that a change be made to comply with the underwriters' rules. I suggested getting a slate board, but it was finally decided that a home-made board would do. Accordingly, I took two pieces of 3x3-in. hard wood, 7 ft. long and mortised in two cross-pieces, making a frame 4 ft. wide, as shown in Fig. 1. This was covered with dry pine boards between the uprights, making a tight back for the form. I next placed the fuse blocks, switch and rheostat on the board and marked where the bolt holes came and where the wires would pass. Through the cross-pieces I bored 5/8-in. holes and drove in wooden pins, leaving them two or three inches long.

For the wires I bored holes to fit porcelain insulation tubes 3 in. long and drove them in as far as necessary. The face of the board was set with 1½-in. screws projecting about one inch and spaced 4 in. each. One-inch boards beveled on one edge to about 40 deg. were mitered even with the inside edge of the form to give a beveled edge to the face of the work when done, as shown in Fig. 2.

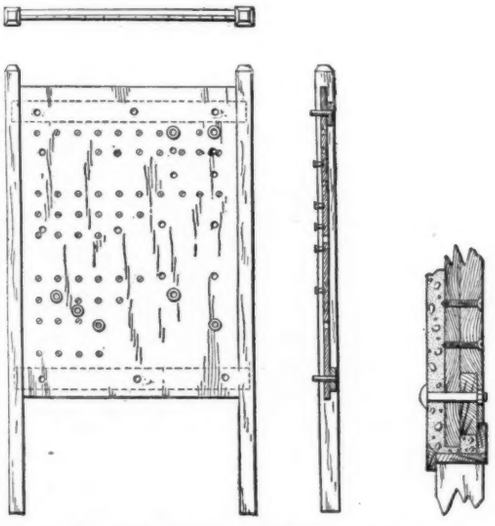


FIG. 1. FORM FOR SWITCHBOARD AND END SECTION

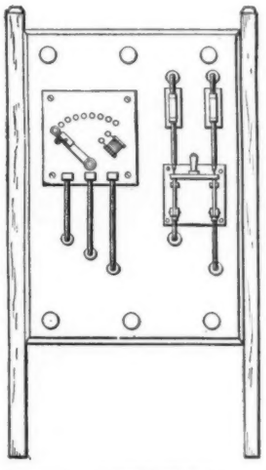


FIG. 2. SWITCHBOARD COMPLETE

Next, I took a straight-edge and laid it across the front of the form and drove the insulating tubes even with the edge and cut the pins the same length. After the wood-work was done I laid the board on two timbers, face side up and leveled it by a straight-edge laid across the sides of the form.

A concrete mixture of one part portland cement to three of fine sand, mixed thin enough to run freely was poured in the form and allowed to set for a week or more. When it was thoroughly dry and hard, the form was removed and the wooden pins driven out through the cross-pieces. The concrete was bolted to the board with 5/8-in. bolts.

The fuse blocks, main switch and rheostat were then fastened in place with ¼-in. bolts through the holes left by driving out the wooden pins. The wiring was mostly at the back of the board; the porcelain tubes serving as passages for making the necessary connections to the apparatus on the front. The back of the board was covered with sheet asbestos for safety and the wires were supported on porcelain cleats. All the conductors were thoroughly insulated from the wood and concrete parts, so that the work passed the underwriters' rules. Finally, the board was painted with a mixture of lampblack and linseed oil, which gave it the appearance of slate. The whole has a good appearance, as shown in Fig. 2 and satisfies all concerned.

J. R. CHAPMAN.

Fairfield, Maine.

Purging Ammonia Condensers

Many people seem to think that a mixture of gases will, when allowed to stand undisturbed for a time, stratify or separate into definite layers, the heaviest at the bottom and the lightest at the top. If this were true, men and animals as now constituted would perish.

The atmosphere is composed of a mixture of oxygen, about 21 per cent.; nitrogen, about 78 per cent.; argon, about 1 per cent.; carbon dioxide, about .04 per cent., and traces of other gases. The heaviest of these is carbon dioxide, with a relative density of about 22; (hydrogen being 1) next comes oxygen at 16 and nitrogen at 14. Were these gases to stratify and maintain a uniform density vertically, corresponding to a pressure of 14.7 lb. per sq.in., and a temperature of 32 deg. F., there would be at sea level a 7-ft. layer of carbon dioxide, then a 190-ft. layer of argon, then 5000 ft. of oxygen, on top of which would be 21,000 ft. of nitrogen. Fortunately, however, the gases do not arrange themselves in layers but tend to become thoroughly mixed because of the operation of forces causing diffusion. Should these forces become inactive, there would be a wild scramble for high ground to reach the oxygen, which, eventually, would burn us up.

In a number of articles on refrigeration, wherein instructions are given on purging ammonia condensers, the authors seem to take for granted that ammonia gas, air and the other gases will separate because of their difference of specific gravity. In *Power* of July 6 Mr. Robertson, in his letter entitled "Purging Ammonia Condensers," states that "air, being heavier than ammonia gas, will by gravity seek the lowest point." Mr. Mathews in his book, "Elementary Mechanical Refrigeration," speaking of the gases present in ammonia systems, says: "If these gases are lighter than ammonia, they will accumulate at the top of the condenser, and if heavier will be driven to the top by the reëxpanding ammonia in the bottom of the condenser as soon as the pressure is removed by the opening of the purge valve." In a volume on refrigeration in the International Library of Technology is the following statement regarding foreign gases: "Fortunately for the operating engineer, the foreign gases formed by decomposition are lighter than the ammonia, so that when a mixture is permitted to remain in a quiet state for some

time the ammonia gas will be found at the bottom and the foreign gases at the top of the containing vessel." In the "Refrigerating Engineer's Pocket Manual" is this: "Carbonic anhydride will fall to the floor by reason of its greater specific weight, and even in the event of a serious leak occurring, the air will not become sufficiently saturated to cause any harm."

These are unqualified statements of a supposed tendency on the part of gases to settle into strata in the manner of some liquids. If gases stratify as stated in the foregoing, what becomes of the kinetic theory of gases? This theory supposes the molecules of gases to be constantly vibrating at a high velocity, the movements carrying the molecules to the confines of the vessel, however distant. A familiar experiment illustrating the diffusive power of gases consists of placing two narrow-necked bottles mouth to mouth, one above the other, the upper one containing hydrogen and the lower one carbon dioxide. After a time it is found that half of the hydrogen has moved into the lower bottle and half of the carbon dioxide has ascended into the upper bottle. Had gases a disposition to stratify there would have been a distinct line of separation in this case, because carbon dioxide is 22 times heavier than hydrogen.

The apparent violations of the law of diffusion, as when carbon dioxide appears to lie dormant in the bottoms of wells and mine workings, is simply because the gas is evolved faster than can be diffused, time being an element in this operation as in everything else. When ammonia leaks from a condenser on the roof of a building the odor is offensive to people on the ground. If gases disposed themselves in layers with the lighter at the top, this would not be the case, and we would have no intimation of the leak until found by inspection.

What actually happens on purging an ammonia condenser is the discharge of a mixture of air, ammonia and hydrocarbon gases. The ammonia discharge is a loss, and for this reason purging should not be carried beyond ridding the condenser as much as possible of the air and the non-condensable gases.

C. O. Sandstrom.

Kansas City, Mo.

Machining a Piston Ring

The study of piston rings is not only interesting but highly important, and great care should be taken in their design, machining, fitting and assembling, inasmuch as the smooth running and, indeed, the economy of an engine depend largely upon them.

From time to time articles on this subject have appeared in *Power* that were obviously meant more for the benefit of the isolated engineer who does more or less of his own repairing than for the expert engineer or machinist. One contributed by S. L. Robinson and printed in the issue of July 6, p. 24, lucidly describes one process of machining a piston ring, and while the writer has no desire to criticize the method described by Mr. Robinson, he does not agree that a ring will not require "facing off" after being parted from the casting. The grooves in the piston should be parallel, and the ring likewise, and it takes only a little longer to turn a part of the end of the casting down, making its diameter a "tapping fit" for the inside bore of the ring to be faced, upon which the ring should hold by friction, and if tapped solidly back against the turned shoulder a parallel ring should result.

As to the circular clearance given the ring, his caution in regard to this point should be rigidly observed, for not only will a ring with too little circular clearance score the cylinder as well as itself, but if it "butts up"—that is, closes at the joint—it may break into pieces. For this reason every ring should be "jointed" in the cylinder by pushing it the whole length, and an opening of ample size should be left in the smallest part of the cylinder. Of equal importance is the side fit, or freedom of the ring in the groove, and many cylinders become scored from a ring becoming "sidebound." Not long ago a firm of engine builders was compelled to install a new high-pressure cylinder to replace one which was entirely cut through at the top on the head end as a result of a tight ring which acted like a scraper when the engine started on its forward stroke with full initial pressure against the follower. After cutoff, the gradual reduction of pressure due to the expansion of the steam relieved the outward strain on the ring and allowed it to close.

Another cause frequently responsible for rings becoming stuck is a round corner at the bottom of the groove, more likely to be found in solid types of pistons than in those having a junk ring and follower, and for this reason the inside edges of the ring should be well rounded. The outside edges should also be given a good generous rounding, as the rounding will grow less with wear, and a sharp corner will scrape off the lubricating oil from the walls of the cylinder.

The method of machining a piston ring will vary greatly, depending on the type of ring wanted, the size of cylinder, design of piston and whether it is to be expanded by springs or be of the "snap" type, depending on the spring in the iron itself for expansion.

The spring of a snap ring will depend on the quality of the iron of which it is cast, the amount cut out, whether it is concentric or eccentric, and also whether or not it is bored on the inside, for once the scale on the inside, or core, is removed much of the spring and half the life of the iron are gone. But it is not necessary to bore the inside of a ring of the "snap" type if care is taken to have the pattern made with a core of the proper size, allowing for clearance over the bottom of the grooves after the ring is cut out, closed and turned to the finished size. Facing off such a ring by the method described will be a little more difficult on account of its not being a bored circle, but with a little patience it can be accomplished.

It has always seemed to the writer only a little short of a crime to take a ring which is assumed to be a true circle—inasmuch as it has been turned in a lathe—and distort it by forcing it over a piston until its inside diameter is greater than the piston size but it is done every day, and engineers will have to keep on doing these stunts as long as solid pistons are made. Many fingers have been and will be pinched, many "cuss words" uttered and many rings broken in this way. When such a job must be done it pays to make so-called "slip irons" out of old hacksaw blades, ground smooth and rounded off at the edges. Four will answer for a fair-sized ring. The temper should be drawn from one end so that they may be bent to form a right angle or letter L. These irons should be placed in position on the piston with the ends (still hard) extending beyond the grooves. It is surprising how much easier the ring can be slipped over

the piston if it is previously immersed in boiling water and allowed to remain there a few minutes. This of course will require the use of a pair of gloves, and the work must be done quickly, before the ring becomes too cool. When in place, the ring should be tested for freedom. If any point on the diameter is tapped or pushed firmly, the point opposite should move; if it does not move freely enough, the spots that are causing the trouble may be touched off with a scraper, without removing the ring, by slipping one of the irons in between the ring and piston, which may easily be done.

While it is not necessary to bore a "snap" ring on the inside, either before or after the joint is cut out, every ring should be finished, turned to size, after being cut and closed, and for this operation allowance in size should always be made in the outside diameter. The necessity for this allowance is that the cylinder bore is assumed to be a circle or nearly so, and the ring was also a circle before it was cut and closed together. With a ring diameter of, say, 8 in. and with $\frac{3}{8}$ or $\frac{7}{16}$ in. taken out and the ring closed again, it is plain that it can no longer be a true circle, and if placed in the cylinder in this condition a leak is sure to result. Suppose that previous to cutting the ring it has been turned outside and bored inside, and is of a uniform thickness throughout its circumference. After being cut, closed and refinished it will not be of a uniform thickness, because both the inside and outside diameters were distorted by closing up the joint, and its circular shape was restored by the turning, the effect being that the sides or points at right angles to a center line drawn from the joint will be the thickest. This can be easily proved by the use of a pair of calipers. It matters little if a "snap" ring is not of a uniform thickness; but it is preferable to have the greatest amount of metal at the spring or at the point opposite the cut, and to insure this it is imperative that in placing the ring in the lathe for the finishing operation that it be so set that the least amount of iron will be sacrificed at this point, producing a ring somewhat eccentric, but all the better for that.

A ring that is to be expanded by springs will require a different method of machining, as obviously it should be of a uniform thickness if anything like equal tension is to be exerted by the springs.

H. R. Low.

Moosup, Conn.

Compound Engine Wrecked

A large compound-condensing engine at the cotton mill plant of the S. Slater & Sons, Inc., Webster, Mass., was wrecked by water, supposedly by the condenser pump stopping. The connecting-rod on the low-pressure side was badly bent and the crank disk on the same side was turned on the shaft nearly an inch.

Both frames were broken off through the jaws of the main bearings and shoved back so that the back quarter box laid flat, badly cracking the foundation. Neither cylinder was damaged.

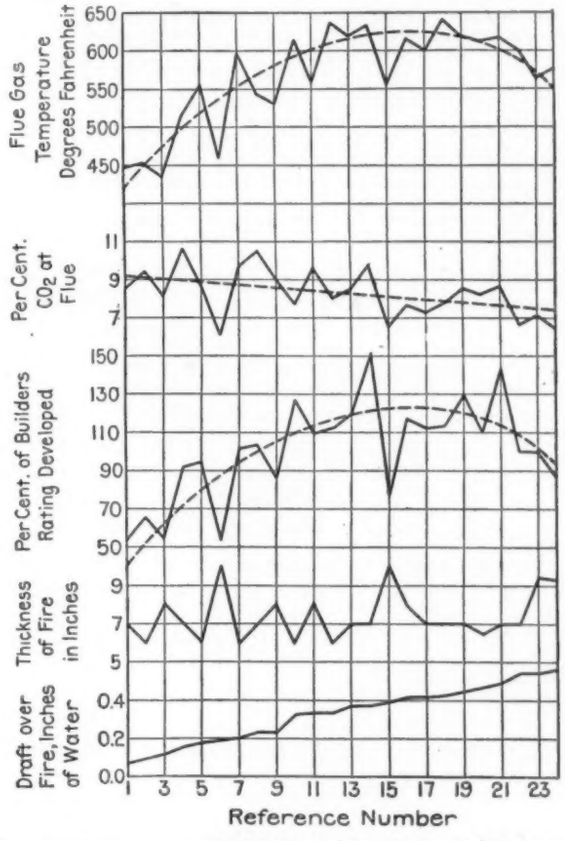
This 26&42x52-in. engine was belted to a 400-kw. generator. It ran at 103 r.p.m.

Two men were in the engine room at the time, but neither was hurt. The accident happened just after starting on Monday morning, July 26.

Southbridge, Mass. P. W. Rollins.

Relation of Factors Influencing Combustion

. The recently published Bulletin No. 78 of the Engineering Experiment Station of the University of Illinois contains some interesting data about boiler tests. A series of twenty-four tests was run on a specially baffled Babcock & Wilcox boiler having a total water heating surface of 5120 sq.ft., equipped with a Green chain-grate stoker with an active grate surface of 90 sq.ft. The object of these tests was to determine the proper conditions for the continuous operation of the boilers in the new power plant at the university, and at the same time make a detailed study of boiler and furnace losses under varying conditions of load, depth of fuel bed, and draft.



RELATIONS OF FACTORS INFLUENCING COMBUSTION

A point not specifically covered in the report of these tests is the relations existing between the draft over the fire, thickness of fire, load, carbon dioxide at the flue, and the temperature of the gases at the flue. The information collected is so admirably reported that it is a simple matter to make a plot of the data so as to show these relations clearly. Any curves so plotted are, of course, applicable only to the boiler on which the determinations were made, but for any boiler having approximately the same ratio of grate to water heating surface the curves of these factors will probably have similar characteristics.

The relation of these five factors to each other is important for the following reasons: The draft and thickness of the fuel bed have a marked influence on the percentage of carbon dioxide, which is the best indicator of combustion efficiency. The temperature of the gases at the flue is greatly affected by the rate of combustion, which in turn is a function of the draft applied, and this tem-

perature has a direct bearing on the size of the dry flue gas loss, which in the majority of industrial plants is the largest single preventable loss. Furthermore, the capacity is closely bound up with the intensity of draft and the thickness of the fuel bed. Consequently if these five factors are determined over a wide range, and the results plotted, the approximate draft for the economical capacity of the boiler can be determined, and the effect of various thicknesses of fuel bed on capacity and economy of operation will be apparent.

The plot shows the relations that may be deduced from this series of tests, and it should be remembered that each point on this chart is an average value obtained throughout a complete test. Attention is especially called to the marked effect produced on capacity, carbon dioxide and flue temperature by the thickness of fuel bed, as shown by tests Nos. 6 and 15. The carbon dioxide and flue temperature were reduced in both these cases by the fact that the fire had to have considerable attention when carried at this thickness, and that consequently the side doors were opened quite frequently. The effect of a change in the thickness of fuel bed when running at approximately the same capacity and with nearly the same draft over the fire is shown by a comparison of tests Nos. 7 and 8, where the carbon dioxide increased and the flue temperature decreased when the fuel bed was thickened and the draft was kept nearly the same. The general rise of the flue temperature with the fall of the carbon dioxide up to a point representing about 25 per cent. overload and its fall thereafter may be explained as follows: As the draft over the fire is increased the velocity of the gases through the boiler is increased and the boiler then has less chance to cool them. When, however, the draft is increased enough the excess air becomes so large that it produces a marked cooling effect on the fires and this shows in the reduced flue temperature.

CARLETON W. HUBBARD.

Brooklyn, N. Y.

Results with Mechanical Soot Blowers on Boilers

In *Power* of May 4 J. Priefer asks for information regarding the operation and results obtained by using a mechanical soot blower. In the plant where I am employed we have two Babcock & Wilcox boilers, each rated at 500 hp. The grates are of the stationary type and are hand-fired under natural draft. The width of the furnace is 12 ft. and the alley between the boilers is 33 in. wide, which makes the operation of hand-blowing particularly troublesome in the hot weather, when our colored help will miss most of the doors unless closely watched. Even when properly done the blowing was not satisfactory on account of the width of the alley, which necessitated the use of a short steam lance.

After the boilers had been in service a year, the management decided to install blowers. The type selected consists of four units extending across the tubes at right angles with the tubes, there being one unit in each pass at the top and one under the baffle wall between the second and third passes. The blowers are rotated by handwheels outside the boiler walls.

The gases go through an economizer, where the temperature is read every hour and marked on the log. The first reading taken after the blowers were used showed that the temperature of the feed water had fallen from 218 deg. F. to 185 deg., with the same condition of fire and load, and the coal per kilowatt hour dropped from 4.42 to 3.6 lb. for the 24 hours. We have no means of measuring the feed water, and I regret that I cannot give any information as to the increase in evaporation, but it must have been considerable. The average temperature of the feed water leaving the economizer before the installation of the blowers was 230 deg., and since using the blowers it rarely reaches 200, the average being 185.

Probably in plants where the conditions are more favorable for hand-blowing the results of the mechanical blowers would not be so pronounced as in our case; but after using them I believe they would reduce the fuel consumption in any plant, large or small. Our blowers are operated twice daily—at 4 a.m., before the day load comes on, and 4 p.m., before the evening peak. Before the blowers were put in it was hard work to carry 500 kw. on one boiler, but now the firemen have no trouble handling 650 kw.

The following is a comparison of coal consumption and kilowatt output for the months of February, March and April, 1914 and 1915:

	1914		1915	
	Coal Consumption, Tons	Kw.-Hr.	Coal Consumption, Tons	Kw.-Hr.
February	428	164,230	408	205,560
March	475	163,090	445	206,190
April	373	123,950	343	152,500

This shows a decrease in coal consumption of 80 tons and an increase of 112,980 kw.-hr. in output for the three months over last year, with coal ranging from $5.30 to $5.50 per ton delivered on a siding. This amounted to a saving of $435 in coal alone, which almost paid for the blowers.

A. J. FISHER.

Miami, Fla., Box 525.

Engineer's Emergency Level

Every engine-room has the means at hand for the construction of the convenient and accurate level described herewith. It is so simple to make as to appeal to anyone.

It consists of a regular gage-glass, nearly filled with water, and with its ends plugged with putty or other suitable material of a cementing nature. The bubble can be made as long as desired, depending on the work for

LEVEL MADE FROM GAGE GLASS

which the level is to be used; and as the glass is straight the bubble will go the whole length of the glass if slightly elevated. The glass being round and usually reasonably straight, it can be turned over without affecting the location of the bubble or the accuracy of the level. Any suitable mark can be used at the middle to indicate when the instrument is level. This is not intended to supplant the regular level, but to serve in an emergency or to go into limited spaces.

A. P. CONNOR.

Washington, D. C.

Inquiries of General Interest

Nonfreezing Liquid for Gage Pipe—Where a steam gage and connections are exposed to cold what nonfreezing liquid can be used for filling the gage and connecting pipes?

J. D. D.

Ordinary kerosene oil is a good nonfreezing liquid that can be used for the purpose.

Operation of Valve Having Neither Lap nor Lead—If a slide valve had neither lap nor lead, at what part of the stroke would cutoff take place?

C. W. O.

The valve would cover the port and the supply of steam would be cut off at the end of the stroke.

Temperatures Required to Precipitate Carbonates in Feed Water—At what temperature can calcium and magnesium carbonates be precipitated in feed water?

W. R.

Precipitation begins when the water is heated to 180 deg. F., and the greater part of the carbonates will be deposited by the time the temperature has reached 212 deg. F. A temperature of about 290 deg. F. is required to precipitate all of the carbonates.

Relative Value of Upper and Lower Rows of Tubes—In a horizontal return-tubular boiler, are tubes of the lowest row as valuable heating surfaces as those of the upper row?

W. M. S.

In average settings of return-tubular boilers the furnace gases are returned from the combustion chamber by easier passages to the upper row of tubes. Consequently the surfaces of the upper row of tubes are swept by larger volumes of heated gases and the tubes are more valuable as heating surfaces than tubes of the lowest row.

Shaking and Dumping Grates—What are the advantages of shaking and dumping grates for hand-fired boilers?

D. S.

When properly handled this type of grate will keep a fire free from excessive ash and will break up clinker formations, so that the passage of air through the fuel bed will be less obstructed, and there will be less waste from cleaning and slicing the fire than with stationary grates. Shaking and dumping grates are therefore especially advantageous for coals that are high in ash or that tend to form objectionable clinker.

Pantograph Reducing Motion—What are the advantages and disadvantages of a pantograph reducing motion for taking indicator diagrams?

R. L. S.

A properly designed pantograph-reducing motion, when in good order and properly applied, has the merit of giving a truthful reduction of stroke, but has the disadvantage of being unwieldy for use in many situations, and unless constructed and used with view of taking up lost motion of the numerous joints, this form of reducing motion has the additional disadvantage of introducing serious errors from lost motion at both ends of the stroke.

Cleaning and Sharpening Files—How are files cleaned and sharpened by chemical treatment?

E. P..

After removing loose dirt with a stiff brush, the files are cleaned of grease by boiling them for about 45 min. in a solution consisting of ¼ lb. of saleratus to a quart of water. The files are then to be thoroughly washed in clean water and dried and then placed on end, completely submerged in a solution consisting of ¼ lb. of sulphuric acid to a quart of water. After remaining in the acid solution for about 12 hr. the files should be thoroughly washed in clean water, quickly dried and given a light coating of kerosene or other thin oil to prevent rusting.

Steam Required to Melt Ice—How many pounds of steam at 100 lb. absolute pressure would be required to melt 20 lb. of ice at 24 deg. F.?

H. C. M.

The specific heat of ice is 0.504 and to raise each pound of ice from 24 deg. F. to 32 deg. F. would require (32 — 24) × 0.504 = 4.032 B.t.u., and upon attaining a temperature of 32 deg. F. each pound of ice would additionally require 144 B.t.u. (called the latent heat of fusion) for conversion of the ice into water at 32 deg. F. Hence to melt 20 lb. of ice at 24 deg. F. would require $20 \times (4.032 + 144) = 2960.64$ B.t.u. A pound (weight) of steam at a pressure of 100 lb. per sq.in. absolute contains 1186.3 B.t.u. above 32 deg. F., and therefore if the steam is condensed and the condensate is reduced to 32 deg. F., then $2960.64 \div 1186.3 = 2.49$ lb. of steam will be required. But if heat is transferred through heating surfaces, and only during condensation of the steam, the condensate being withdrawn at the temperature of the steam, then each pound of steam will part with only its latent heat or 888 B.t.u. and the quantity of steam required will be $2960.64 \div 888 = 3.33$ lb.

Degrees of Superheat and Total Heat of Superheated Steam—If steam at a gage pressure of 135 lb. per sq.in. has a temperature of 465 deg. F., what would be the degrees of superheat and total heat per pound?

L. W. J.

By referring to Marks and Davis' "Steam Tables and Diagrams" it is seen that the temperature of saturated steam at a pressure of 135 lb. gage or 150 lb. absolute is 358.5 deg F. Hence a temperature of 465 deg. F. would indicate $465 - 358.5 = 106.5$ deg. superheat. The steam tables will also show that for a pressure of 150 lb. absolute and 100 deg. superheat the total heat per pound of steam would be 1249.6 B.t.u. and for 110 deg. superheat, 1254.8 B.t.u Interpolating between these values, the total heat for 106.5 deg. superheat is found to be

$$1249.6 + [(1254.8 - 1249.6) \div (110 - 100) \times (106.5 - 100)] = 1252.98 \text{ B.t.u.}$$

Size of Return Tank for Steam-Heating System—Where two 150-hp. boilers are used to supply steam-heating apparatus and the return water is gathered in a vented receiving tank from which it is returned by a feed pump to the boiler, how would the proper size of receiving tank be determined?

W. W.

To cover emergencies the receiving tank should be large enough to hold as much water as would be gathered in the receiver if the pump were out of operation for about one-half hour. With two 150-hp. boilers steaming to their capacity, and the water returned from the heating apparatus as rapidly as the steam was condensed, the water would amount to about $150 \times 30 = 4500$ lb. per hr.; therefore the tank should have a capacity of 2250 lb. or $2250 \div 62.3 = 36.1$ cu.ft. of water. Employing a tank 3 ft. in diameter the length required would be $36.1 \div (3 \times 3 \times 0.7854) = 5.1$ ft. or, practically, a tank 36 in. in diameter by 60 in. long would be large enough for all probable requirements.

Effect of Increase in Back Pressure—Where 4-lb. back pressure is carried on an engine for warming buildings with exhaust steam, it is proposed to increase the engine back pressure to 15 lb. for the purpose of supplying exhaust steam to coils of drying kilns which at present are supplied with live steam at from 10- to 151 p-.bressure. Assuming that the engine is capable of developing the required power, what effect would the increase of back pressure have on the economy of the plant?

P. C.

In developing the same power, an increase of back pressure would require the engine to be supplied with more steam, but as more heat would be required for conversion into work, the exhaust would contain as much additional heat as was supplied to the engine. Hence, assuming that the additional heat in the exhaust would be utilized without changing other conditions, then the cost would be the same as though the heat was supplied by steam taken directly from the boiler. Therefore, if increasing the back pressure to 15 lb. can be accomplished by no greater waste of heat of the exhaust—as by discharging surplus exhaust to the atmosphere through a back pressure valve or by condensing it in a vacuum pump—then back pressure can be increased without detriment to economy, and any arrangement by which less heat of the exhaust is wasted will be attended by greater plant economy.

Power-Station Economics*

SYNOPSIS—Power plant conditions must be studied more thoroughly in order to avoid false economy and to base maintenance or improvement expenditures on actual facts.

In steam-electric plants raw materials and labor are utilized to produce electrical energy. It is an economic process and power-station economics might therefore be defined as the science of producing electrical-energy wealth. In other words, it is a detailed study of the methods of producing electrical energy viewed from a dollars and cents standpoint.

During the past six or eight months many engineers had to cut down operating expenses, and although the stress of conditions has not yet been entirely removed, it is possible to look back on the efforts at economy and note their effectiveness. Certain economies were introduced, knowing that they would not prove permanent; others were simply a postponement of expenditures; but still others must surely have been made that will prove lasting. There is a class of savings, however, which are not effective because they are only surface savings.

Not long ago the writer, in making some tests in a plant, noticed an open-ended 1-in. pipe leading down the side of a boiler. The valve on this line was leaking steam—not badly, but nevertheless, it was a noticeable leak. Following a friendly argument regarding the size of this leak, a pail of cold water that had been previously weighed was hung so that the pipe projected into the water. The pail of water increased in weight at the rate of 14 lb. per hr., or 336 lb. of steam per day. The fuel cost of 336 lb. of steam at this plant was approximately 7c. This amounts to $2.10 per month, or $25.20 per year. A new 1-in. globe valve of the best type could have been purchased and installed for $2. A new valve on this line, assuming the old one to be beyond repair, would have more than paid for itself every month. The surface saving in this case was the price of the valve plus the cost of installing it, or $2. Really there was a loss since the leak was costing the price of the valve every month or at the rate of twelve times per year. It is this false economy that is keeping many a plant from making a good showing.

WHEN REPAIRS WILL PAY GOOD DIVIDENDS

Why hesitate to spend $1000 on a turbine if the money is saved in a year through higher steam economy? Yet in many plants such repairs are postponed until the loss through inefficiency each month is nearly equal to the cost of the repairs.

Take, for example, a 5000-kw. turbine having a water rate of 15 lb. of steam per kw.-hr., not including auxiliaries. This turbine might generate in 24 hr. on an average, say 50-000 kw.-hr. With steam costing 20c. per 1000 lb. the daily cost for steam alone to operate the turbine is $150, or $4500 per month. Through defective or worn blading the water rate might increase from 15 lb. to 16 lb. per kw.-hr. This increase of 6.7 per cent. costs in actual cash $300 per month, or $3600 per year. If the water rate goes up to 17 lb. per kw.-hr., the additional cost is $7200 per year; and if it goes up to 18 lb., the increase in cost is $10,800 per year. There is a point in the gradually increasing water rate of the turbine where it will pay to make the necessary repairs to bring the steam consumption back to normal. Local conditions make each case a separate problem, but the problem should not be settled by snap judgment.

Unfortunately, there is frequently a strong tendency toward considering maintenance and operating expenses separately. They are so interrelated that one cannot be changed without affecting the other. The practice of indiscriminately hammering down maintenance, which is carried out in some plants, is much to be deplored. It is almost sure to defeat its own purpose, namely, that of making a saving. Where "hard times" are at hand, it is not an uncommon thing to send out an order something like this: "Let every man go that you can possibly get along without, and do not spend a dollar except when necessary to keep the plant running." Of course, the plant superintendent is supposed to interpret and apply the order in such a way as to cut down the overall expenses of the plant. Why not say to him, then: "Turn off every man who is not saving his wages, and do not spend a dollar that will not be returned inside of a month." Make it two weeks, two months or a year, but do not discourage spending money to save it, provided the return is adequate to the circumstances.

WHY MAINTENANCE COST IS AN INVESTMENT

Decide proposed maintenance or improvement expenditure, whether large or small, on the basis of "how long it will take to pay for itself." Large expenditures are usually viewed from all standpoints and receive proper consideration. The opportunities for making small expenditures, however, which produce large returns are of special interest since they are often neglected or passed upon hastily. There is no argument that would justify the leak in preference to repairing the 1-in. valve or installing a new one. How many times has a few dollars worth of paint on the boiler settings increased their efficiency and paid for itself every day or every week? The length of time it will take to pay for covering a bare steam pipe is only a simple problem in arithmetic. It is not an easy nor inexpensive job to repair the baffles in certain types of boilers, yet it is not an uncommon thing to reduce the flue temperature 100 deg. by so doing and thereby pay for the work in two weeks.

But the opportunities to spend money in a power plant are innumerable. The point which it is desired to bring out here in regard to maintenance is this: Do not think about maintenance as an expense to be kept as low as possible, but rather as an opportunity for investment that will pay unusually large rates of interest.

Occasionally, men in charge of plants say that they know all of these things ought to be done, but they cannot get the "boss" to see it. The trouble with these men usually is that they have not gotten down to brass tacks and proved to the "boss" beyond all reasonable doubt the money-making side of the proposition. Many times, an examination of this sort, made beforehand, proves conclusively that the proposed expenditure is questionable as an investment. A man just out of college and employed by a company operating a number of power plants recommended in a general way the repair of a pipe covering, at that time in bad condition. Nothing was done about it, however. Later, an older and more experienced man got the work done by sending the office a detailed estimate of the cost, the saving which it would effect and photographs showing the need for the work—all gotten up in the form of a report which was indisputable. Power-plant needs must be translated into terms of dollars coming back for every dollar spent, before they receive much attention from the man whose word is final. Those who have to do with power plants bank too much on judgment. Good judgment is one of the most necessary qualifications in a power-plant operator, yet judgment not based on facts, when the facts are available, is frequently nothing more nor less than a guess. Why should a man's judgment tell him that a new 1-in. valve was not worth while, when there were facts to the contrary? Why depend on judgment to tell when it is time to reblade turbines, when definite facts can be obtained?

SOME PRACTICAL EXAMPLES OF ECONOMY

In a good-sized power plant the exhaust from the engine, turbine auxiliaries and large air compressor was allowed to escape into the circulating-water discharge duct. Surely, a careful analysis of conditions in this plant would have found some place to utilize this exhaust steam. Its use in the feed-water heater, for instance, would have resulted in a material fuel saving. The plant was equipped with economizers, and it was not thought necessary to heat the feed-water above 120 deg. in the feed-water heater.

A 400-hp. boiler which had not been turbined for six months was found to increase in efficiency 4 per cent. on being cleaned. This was equivalent to a fuel saving of 5½ per cent., or about $2.20 per day. Here was another case of trusting to judgment as to the proper interval between cleanings.

In another plant a motor was used for stoker drive. The auxiliary steam engine was allowed to remain idle. Reversing this order and exhausting the engine into the feed-water heater effected a saving of about $2 per day.

Power-plant conditions are ever changing, and operators should be continually on the alert for opportunities to improve. In well-operated plants tests are continually made to discover better methods of operation. Plants in which this is not done are going down hill, for a plant is either pushing ahead or it is going backward. Of great assistance in the analysis of plant operation are the recording instruments now available. Newly built plants are equipped for

*From a paper read before the Missouri Public Utilities Association by E. J. Billings, of the Doherty Operating Co.

weighing the coal to the individual boilers. The boilers have steam-flow meters to show the rate of operation. The total water fed to the boilers, the makeup water and, if surface condensers are used, the hotwell water from each unit are metered. Numerous recording temperature and pressure gages are used, so that the daily station log sheets have the appearance of a 24-hr. plant test. Old plants find some trouble in equipping with modern instruments throughout, but the essential ones can usually be installed without serious complications. There is frequently some reluctance about purchasing new instruments, when the plant has always gotten along without them. A power plant with only such instruments as are absolutely necessary for operation is like a merchant who keeps no books other than counting his cash at night. After the close of business, if he suspects he is not making money, he has only his good judgment to refer to in searching for the reason why.

ANALYSIS OF HEAT LOSSES IMPORTANT

Consider for a moment a plant having an operating expense of, say $10,000 per month. Of this amount probably $7500 will be spent for fuel and the balance for wages, miscellaneous supplies, and upkeep. In other words, $7500 will be paid for the source of energy for operating the plant. Of this $7500 worth of heat units about 10 per cent., or $750 worth, will reach the switchboard as electrical energy. The balance, costing $6750, is lost in the transformation. A little study will show where this $6750 worth of heat units goes. Assuming that the plant is well operated and efficient, the losses in heat units each month will be somewhat as follows:

Unburned fuel in ashes	$375
Heat lost up the chimney	1375
Friction radiation and heat used for miscellaneous purposes	500
Heat carried away by circulating water	4500
Total heat losses	$6750

Adding to this the value of the heat-unit equivalent of $750 that finally reaches the switchboard gives the total amount originally spent for fuel.

If nature had provided that plants be operated with dollar bills instead of heat units, we might easily picture the general manager's car standing in front of the plant at least three or four times a week. The company's secretary would have a desk at the plant. There would be numerous clerks with numerous instruments and devices to prevent dollar bills from unnecessarily floating up and out of the stacks. The chemical laboratory would work day and night to detect dollar bills in the ashpile. The circulating water and condensers would be guarded with the greatest of care lest a few dollar bills slip away which might be retained for the switchboard. If the company's secretary were asked, "Why all this fuss just because we are running on dollar bills?" he would throw out his chest and reply: "My goodness, man, that pile of dollar bills represents 35 per cent. of the company's operating expenses." The general manager would nod assent and say: "Yes, I know these precautions all cost money, but just think of the dollar bills we might lose and never know it." Even though plants must be operated with heat units instead of dollar bills, it is possible to know just where these heat units are going at all times.

HUMAN ELEMENT IS POWER-PLANT ASSET

Another element in power-plant economics is the station employees. As a rule a plant is no better than the men who run it and the employees are no better than the plant. Either the plant draws the men to its level or vice versa. A clean, orderly and well-operated plant develops similar qualities in its employees. A man who is not in harmony with his surroundings soon drops out. This tendency in a plant toward either better or worse, therefore, constitutes the policy of the plant and is determined, to a certain extent, by the policy of the company.

In some plants the true policy is not as readily apparent as in others, and then again in some plants a strong policy is felt the moment one enters the building. The greatest advantage, and it is an economic one, too, in a clean, orderly and systematically operated plant is that it keeps before the employees, every hour of the day, the general policy which is being followed. The real aims and purposes in such a plant are carried out cheaper and more effectively, and the investment, if it is so considered, is a profitable one.

Good will is another asset to a power plant, just as it is in business. Coöperation is another word for the same thing. The old-school engineers used to guard their knowledge and purposes as carefully as their bank accounts. The oiler who was even allowed a glance at the indicator diagrams taken from his engine was indeed a lucky oiler. These customs have been done away with, and the employees are helped to help themselves. The management makes friends of them and encourages their self-respect by providing them with lockers, shower baths and other conveniences, so that when they go out on the street they are not ashamed to meet their friends who have "white-collar" jobs. All of these things are done because it pays, and any plant whose policy does not include efforts along this line is overlooking something of great importance.

It is important to dig deeper into power-plant conditions than has been done before. This cannot be done alone by walking through the plant, casting searching glances here and there—by feeling of this or listening to that. The old-school engineer did all of these things. It is necessary to do this and more. Get busy with pencil and paper, instruments, charts, log sheets and records, and learn exactly how, when, where, why and how much. Good judgment based on these facts may produce little-dreamed-of results. Then, too, do not forget the power-plant policy, for it is vital in the operation of the plant. If it is a bad one, revise it. If it is a good one, look it over and make sure nothing has been neglected.

Recent Court Decisions

Digested by A. L. H. STREET

Duration of Municipal Franchise—An ordinance granting an electric power company the right to maintain its poles and wires in the streets of a city without limitation of time is a perpetual grant unless the city's charter or some statute limits the duration of such grants. (United States District Court, District of Oregon; Ashland Electric Power & Light Co. vs. City of Ashland, 217 "Federal Reporter," 158.)

Employer's Duty to Employees—When employees of a power plant are sent from time to time to the roof of the engine room to clean steam condensers or perform other duties, the employer is under legal duty to provide a reasonably safe place for doing the work, and is liable for injury resulting from failure to perform this duty. (United States Circuit Court of Appeals, Sixth Circuit; Tompkins vs. William Sebald Brewing Co., 221 "Federal Reporter," 895.)

Contributory Negligence of Engineer—An engineer in charge of a power plant cannot recover for injury sustained by him through the coming off of the wheel on a valve stem, while he was attempting to turn it, if it was part of his duties to repair such defects and proper tools for the purpose were furnished him, decided the Appellate Division of the New York Supreme Court in the recent case of Schoonmaker vs. N. Y., O. & W. Railway Co., 152 "New York Supplement," 1079.

Appropriation of Water for Power Purposes—When the waters of a stream are claimed adversely by two persons, one asserting an appropriation for development of water power and the other for irrigation, in considering the rights of each due consideration should be had for loss of water through leakage in ditches and flumes, if reasonable care is used to avoid unnecessary loss. (Oregon Supreme Court, Joseph Milling Co. vs. City of Joseph, 144 "Pacific Reporter," 465.) A company that has merely acquired the right to use the waters of a stream for power purposes, and that uses them only during certain months of the year, cannot confer any right on a third person to use the waters for irrigation purposes, as against a second party. (In re North Powder River, 144 "Pacific Reporter," 485.)

Implied Warranty of Machinery—When machinery is manufactured and sold for definite use in a steam-power plant, the manufacturer will be deemed to have warranted to the purchaser that the appliances are reasonably well adapted to that purpose, unless there is something in the contract to show that there was an express understanding that there should be no such guaranty. The Nebraska Supreme Court recently applied this rule to a sale of a stoker. After the device was installed in the food-manufacturing plant of the purchaser, it was found that it could not be operated without filling the plant with smoke and gas fumes to such an extent as to seriously interfere with operating the factory. Thereupon, the purchaser gave notice of rejection of the stoker and ordered the seller to remove it. This not being done, the purchaser removed the machinery at his own expense and when the seller sued to recover the agreed price of the stoker, succeeded, not only in preventing such recovery, but in getting an affirmative judgment for the expense of removing the stoker and for damages suffered on account of its failure to work properly. (Underfeed Stoker Co. vs. Farmers' Coöperative Creamery & Supply Co., 152 "Northwestern Reporter," 741.)

Use of Coal and Production of Cheap Power*

Manufacturing industries are becoming more and more dependent on mechanical power, and the substitution of the latter for manual labor is extending year by year in all industries. Even in the Lancashire textile industry great changes are impending. A process has been invented and applied for producing textile fabrics from a solution of cellulose, without either spinning or weaving as an intermediate step. Much of the material now used in Paris for making women's hats is manufactured from cellulose by a mechanical process. Here in England (and also in the United States) the chief source of mechanical power is coal, and there is no doubt that our resources of fuel have in the past been most lavishly and unwisely used, and even squandered.

The English Royal Commission on the subject has concluded that our resources of mineral fuel will suffice for many generations, but at the same time we ought to conserve a raw material that cannot be replaced. Assuming the correctness of these conclusions, there is still some cause for uneasiness. While the cost of coal to the manufacturer is increasing every year, the facilities for transporting goods from one country to another also increase, so that foreign competition becomes more keen. If the sources of supply were uniformly distributed throughout the world, no nation would have cause for anxiety; but recent events have shown that a nation cannot safely depend on its neighbors for raw material. Therefore the manner in which we use our vast supply of coal is of the greatest importance. Dr. Beilby has estimated that more than half the coal used for the production of steam power is wasted. Even with the most economical steam plant available this method of producing power is wasteful when compared with other methods now in practical use.

CONVERTING COAL TO GAS IN THE MINES

Theoretically the gas engine is more efficient than the steam engine, but difficulties in the design and running of large engines have hindered the development of large gas-power installations. Still these difficulties are not insuperable and in the opinion of the speaker an enormous saving can be effected by extracting coal from the face of the seam by mechanical means, converting it into gas in the mine, producing electricity from the gas at the surface, and transmitting it any required distance.

When we require only power from the coal, it seems a stupid thing to raise the coal, ash and all, to the surface by mechanical means, when it is possible to produce gas in the mine that will raise itself. There is not the slightest doubt that, though the difficulties are great, this can be done. Even when coal is mined and carried to the surface in the usual way gas is even now the cheapest form of power we have in England.

Gas produced from other materials than coal has been successfully used, as, for instance, from peat, waste wood, and tan; but these materials are never likely to become general sources of power. They can be employed profitably in particular circumstances, and the byproducts they yield are very valuable.

Oils can of course be used in internal-combustion engines for power production, but as other more profitable uses can be made of them, and as heavy oils are now being refined in order to yield substitutes for gasoline, they can never become a source of cheap power.

WATER POWER DEVELOPED FROM THE WAVES

Water is the greatest rival of coal for cheap power production, but Great Britain has not sufficient catchment areas, the rivers are too small, and the height of the mountains is insufficient to yield the water power obtainable in some Continental countries. There are, however, areas with heavy rainfalls at high altitudes in the United Kingdom, from which water power might be obtained, and the speaker believes that, if these sources of power are ever developed, they should be acquired by the government and used for the benefit of the whole nation. The greatest water power we possess is undoubtedly that of the waves. This does not refer to tidal movements, although the energy to be derived from them would be considerable, but to the ceaseless pulsation of the ocean upon our shores. The average height of the Atlantic waves is about 5 ft. and the interval between them about 20 sec. A wave 5 ft. high, and 150 ft. long produces energy equal to 10 hp. Many no doubt effective inventions have been devised for utilizing wave power. The chief reasons why they have not been applied are, (1) that in years gone by the cost of making the necessary apparatus was too great, (2) the cheapness of coal, and (3) that the electric transmission of power was not worked out. At present the plant can be made cheaply, coal is much dearer and when a simple and cheap method of storing energy is discovered, the waves will be a great source of power and coal will become an important raw material for the chemical industries. Burning coal in the ordinary way is a waste of valuable byproducts. Methods and appliances already exist for separating and utilizing the constituent parts of coal in the most efficient manner.

SOME DISCUSSION OF FUEL ECONOMY

Professor Bone, of London, suggested the establishment of a fuel-control department in all large factories, and stated that in works where this had been done great saving was effected in the expenditure for coal.

Professor Louis, of Newcastle, said that the war would permanently increase the price of coal, and the cost of power obtained from coal would rise proportionately. It is unlikely that the gas engine will ever replace the steam engine. The two methods of power production will continue side by side. As to the production of gas underground, it would be very difficult to obviate the dangers of explosion caused by the accidental escape into the mine of carbonic-oxide gas from the plant.

The greatest fuel waste at present in the United Kingdom was occurring under ground, for there were collieries where 15 per cent. of the coal was left in the pit because it was of the class known as "small coal" and would not pay for haulage and raising. This wasted small coal, from the power engineer's point of view, however, was quite as valuable as the larger fuel raised from the pit, and the colliery proprietors for their own end were wasting a national asset. This was a case in which the government might properly interfere.

*Report of a paper presented by Walter F. Reid, July 16, before the Society for Chemical Industry, Manchester, England.

Government Gets Back $5000 Overpaid Bonus

The District Court of the United States for the Eastern District of Pennsylvania, recently found in favor of the Government in the case of the United States vs. the D'Olier Engineering Co. of Philadelphia, Penn., in the sum of $4999.79.

Through the Isthmian Canal Commission the government contracted with the D'Olier Co. for the installation of two boiler plants, one at Gatun and the other at Miraflores. The Government agreed to pay to the company $1000 for each point in efficiency the boiler attained above 65 per cent. The engineers in charge of the tests computed that the boiler at Gatun showed 79.72 per cent. and the one at Miraflores 82.59 per cent.

In "Power" for Nov. 29, 1910, there were published the acceptance tests of these boilers, and the high efficiency of 82.36 per cent. was remarked. In the Jan. 24, 1911 issue of "Power," there was printed a letter from Prof. Wm. Kent, in which he pointed out that there was an error in the figuring of the tests and that the efficiency should have been not over 76 or 77 and probably 75. It would seem that this was the beginning of the suit, for immediately after this the Government began action against the D'Olier Co. to get back the sum of $10,331.65.

Connecticut's New Boiler Law

At the last session of the Connecticut Legislature an act was passed which repealed sections 4890 to 4898 inclusive of the General Statutes, thus giving the state a new boiler-inspection law.

Under this law the governor appoints "a suitable person" in each congressional district to inspect boilers. The term of office is three years. According to section 2 of the new law, each inspector shall, at least once in each year, inspect all boilers except the following: Boilers of railroad locomotives subject to inspection under the provision of Federal laws, portable boilers used in pumping, heating and drilling in the open field; portable boilers used for agricultural purposes, and in the construction and repair of public roads, railroads and bridges; boilers on automobiles, boilers on steam fire engines, boilers carrying a pressure of less than 15 lb. per sq.in. which are equipped with safety devices, boilers under the jurisdiction of the United States, boilers inspected under a city, town or borough company, which is incorporated under the laws of any state in the United States, which maintains a corps of steam boiler inspectors, which complies with the provision of the General Statutes.

The fee for inspection is $5. For refusal to permit inspection, or for allowing a boiler to carry steam at a greater pressure than that allowed by the certificate of inspection,

a fine of not more than $200 may be imposed. Working a boiler the use of which has been forbidden by the inspectors is punishable by a fine of not more than $1000, or imprisonment of not more than six months, or both. An inspector who falsely certifies as to the condition of any boiler, or who issues a certificate of inspection without having made a thorough inspection, is liable to a fine of not more than $500, or imprisonment for not more than six months, or both.

How the Inspector Does It

I always carried in my kit two light but strong steel chains and two small Yale padlocks. Whenever I had to go into one of a battery of boilers I always made sure that the steam valve and the feed valve which prevented hot water or steam from reaching me from adjacent boilers were so chained and locked that they could not be opened while I was inside the boiler to be inspected. It doesn't do a man's nerves any good to hear a laborer working around the valves which cuts his boiler from those under pressure on either side of him. But the little chain and padlock does ease a man's mind wonderfully while he is inside.

I had been all through, inside and outside, of a large return tubular boiler and had found nothing wrong, but intended to report adversely regarding the covering of the boiler, which was of brick, laid in arched form over the top of the boiler—a very bad arrangement, as will be shown later, but one which was largely in use in cold latitudes several years ago, but happily seldom seen nowadays.

I was inside the boiler, had looked at both heads and had worked my way back to the manhole, in readiness to come out of the boiler. From some cause or other, not clear to me even now, I rolled over on my back and laid there a few seconds, looking around at everything I could see, and apparently everything was in good shape. I was just going to swing myself up into the manhole when a streak on the boiler shell about two feet from the manhole happened to catch my eye, and from force of habit, the streak of rust being a trifle different in color from the rest of the boiler shell, I struck the spot with my hammer. But that blow started something. I did not like the ring from that blow and struck the shell many times around and in that streak of rust; then I got out of the boiler, located the spot on top and tore off a section of the brick covering and laid bare the shell.

I did a deal more hammering there and dislodged a great mass of rust and corrosion where water from a leaky pipe overhead had been seeping down through the brickwork upon the boiler shell for several years. When the boiler was shut down there was no water in the pipe and no leakage, hence no inspector had caught the fact.

After digging and hammering all the rust away the shell at the rusted place was found so very thin that a well-directed blow from the pene of my hammer went right through the shell!—The Boilermaker.

Resistance and Inductance of Iron and Bimetallic Wire

When a direct current flows in a wire, the distribution of the current is uniform over the cross-section of the conductor. When, however, an alternating current flows in a wire there is a tendency for the current to crowd to the outside. This phenomenon, which is caused by differences in the opposition to the current flow in different parts of the conductor, becomes more pronounced the greater the number of alternations of the current in a given time and, in iron wires, the greater the current in the wire. In some cases the flow of current is confined almost entirely to a thin shell on the outside of the wire, and hence arises the term "skin effect" for this phenomenon. The effective resistance of the conductor increases as the frequency of the alternations increases, and at the same time the inductance, which depends on the magnetic field, is diminished. This effect is not only of interest from a purely scientific standpoint, but is frequently of importance in engineering practice.

When the conductor is of simple form and the magnetic permeability of the material is known, the effective resistance and inductance can be calculated by formulas which have been developed. The investigation, the results of which have just been published by the Bureau of Standards, in Scientific Paper No. 252, was concerned with the skin effect in conductors containing iron. Two classes of conductors were considered in particular—the iron telegraph and telephone wires and copper-clad bimetallic wires. The latter have a core of steel surrounded by a shell of copper. The effective resistances and inductances of these conductors were determined experimentally for different strengths of current and for frequencies up to 3000 alternations per second. The results for iron wires obtained with very small currents were compared with values computed by known formulas and the agreement is fairly satisfactory. Formulas are developed in this paper which permit a similar comparison between measured and computed values for the copper-clad wires. The paper concludes with wire tables computed by means of the new formulas. In these tables the effective resistances and inductances of copper-clad wires are given for wires of different sizes and conductivities and for frequencies up to 3000 alternations per second.

Engineers' Advice for New York State Constitution

The committee of engineers representing national and local engineering societies has requested the Hon. Elihu Root, chairman of the New York State Constitutional Convention, to give his consideration and support to certain principles that the committee believes should be incorporated in the state Constitution.

The committee's recommendations relate to the creation of departments of engineering and public works and of public utilities. The former would have sole management of the various engineering activities of the state, control of state lands and buildings and jurisdiction over all conservation projects. The department would be headed by three commissioners, each holding office for twelve years. It would be stipulated that at least one commissioner must be an engineer with experience fitting him for the office. These principles have been incorporated in a bill and presented before various convention committees.

These committees, however, have submitted to the convention amendments that differ greatly from those recommended by the engineers' committee. In the recommendations of the convention committee the control of public works, with the exception of park control, is concentrated in a department of public works to be administered by a superintendent appointed by the governor and removable at will, thus rendering his tenure of office dependent on political exigencies.

The convention committee proposes that state lands and forests be controlled by a nine-headed commission, each member to have a nine-year term, and moreover that the conservation restrictions of the present constitution should be retained. The engineers' committee believes such a commission is too large and also that a competent commission should be free to develop state natural resources scientifically.

The committee of the convention proposes two five-headed public utility commissions, with term of office of five years. No qualifications are required. The engineers' committee not only suggests a single five-headed commission, holding office for ten years, but also that each member should have had experience in connection with public utilities.

The societies represented on the engineers' committee comprise the American Society of Civil Engineers, the American Institute of Electrical Engineers, the New York Section of the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Consulting Engineers, the Municipal Engineers of the City of New York, and the Brooklyn Engineers' Club, with a membership collectively of approximately 30,000, of whom about 6000 reside within the limits of the State of New York.

Water Power Developments on the Nipigon River

On the Nipigon River, which has its outlet on the north shore of Lake Superior in the Thunder Bay district of Ontario, is one of the largest and best of the undeveloped accessible water powers in the Dominion of Canada. The total descent is said to be 250 ft., of which nearly 175 ft. could probably be utilized. The hydro-electric commission of the Province of Ontario made the following report as to the head and power available at different localities along the river:

Locality	Head, Ft.	Estimated Low-Water Flow, Cu.Ft. per Sec.	Minimum 24-Hr. Power, Hp.
Cameron Rapids.....	39.0	5,500	19,500
Splitrock	15.0	5,500	7,500
Island Portage.....	9.5	5,500	4,750
White Chute.....	12.0	5,500	6,000
Victoria Rapids.....	10.0	5,500	5,000
Camp Miner Rapids...	7.0	5,500	3,500
Virgin Falls.....	25.0	5,500	12,500
Flatrock	38.0	5,500	19,000

The Nipigon River is the largest stream entering Lake Superior, and its drainage basin covers an area of over 6000 sq.mi. in a rocky district where the average annual rainfall probably exceeds 20 in. Lake Nipigon could be converted into an excellent storage basin at a relatively small expenditure, permitting the regulation of the flow and rendering it possible to increase the rate of flow above the minimum given in the commission's report.

At the present time the nearest large centers of population are at Port Arthur and Ft. William. The distance from Port Arthur to the Canadian Pacific Ry. bridge over the river is about 66 mi. A power plant at Cameron Pool would be 14 mi. and one at Virgin Falls about 30 mi. north of the railway, and each would be about 85 mi. from Port Arthur.

The Nipigon River powers will probably best serve pulp and paper mills or electric smelting plants situated on Nipigon Bay, where the shores give an excellent opportunity to establish good wharf facilities.

OBITUARY

CHARLES A. POTTER

Charles A. Potter died Aug. 8 at Providence, R. I., where he had been for 20 years United States local inspector of boilers. He was born at Wickford, R. I., in 1854, and after a brief business experience became an engineer on the Providence & Stonington R.R. He was later made chief engineer of a steamer plying between Newport and Narragansett Pier. After this service Mr. Potter became chief engineer of the New Bedford, Nantucket & Martha's Vineyard Steamboat Co.'s fleet, with headquarters on the steamer "Gay Head." A tribute from the Providence "Evening Bulletin," which is peculiarly fitting to the work of the engineer, is given below:

The service which the late Charles A. Potter performed as a Federal official in the inspection for many years of the boilers of the steam vessels entering the waters of the Providence district placed him in an important relation to the traveling public which the latter rarely realized. His was duty which the public does not see performed, and so long as no boiler failures occur attention is seldom called to the evidence that the work has been well done. In a time when the Federal steam vessel inspection service was less efficient than it is today there was a wide impression among vessel men concerned with the mechanical department that Mr. Potter's judgment and vigilance were far above the average in the country. That he served the Government and the public with great fidelity, although without conspicuousness, there seems no doubt. His peculiar back-handed signature affixed to certificates of hundreds of steam vessels for many years past meant much to marine engineers, and it will be missed.

PERSONALS

O. P. Hand, formerly advertising manager of the Minneapolis Iron Store Co., Minneapolis, has been appointed director of publicity for the Burd High Compression Ring Co., of Rockford, Ill.

John J. Hunt has resigned his position as superintendent of the water and light department of Mt. Forest, Ont. He will enter the engineering and electrical business for himself at Oakville, Ont.

George A. Ditty, of Portsmouth, Ohio, has been appointed chief assistant examiner in the division of steam engineers under the Ohio State Industrial Commission, with offices at Columbus. Mr. Ditty has held a number of responsible engineering positions in Portsmouth, including those with the city water works, the Street Railway & Light Co., and the Scioto Hominy Co. He is a member of Local Order of Stationary Engineers No. 77, International Union of Steam and Operating Engineers, No. 558, and of the National Association of Stationary Engineers. As a member of the last-mentioned organization he was a national delegate to Springfield in 1913 and Milwaukee in 1914, and is a delegate to this year's Columbus convention.

Dr. Addams Stratton McAllister has resigned as editor of the "Electrical World." Dr. McAllister is widely known in the electrical industry, not only through his connection with the "Electrical World" but because of the electrical papers and books he has written and the prominent part he has taken in the work of many electrical organizations. He was born in Covington, Va., in 1875 and was graduated from the Pennsylvania State College in 1894 with a degree of B.S. and subsequently received the degree of E.E. For several years he was in the shops of the Westinghouse Electric & Mfg. Co. at East Pittsburgh. He took a post-graduate course at Cornell University, receiving the degree of M.M.E. in 1901 and of Ph.D. in 1905. From 1901 to 1904 he was instructor in physics and applied electricity at Cornell, and in 1904 was made assistant professor of electrical engineering. He joined the staff of the "Electrical World" in 1905 as associate editor and in 1913 was appointed editor-in-chief. For the past year he has been president of the Illuminating Engineering Society. He is a Fellow and Manager of the American Institute of Electrical Engineers and is a member of the American Society of Mechanical Engineers, the National Electric Light Association, the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, the New York Electrical Society and the American Electro-Chemical Society. His plans for the future have not been announced.

ENGINEERING AFFAIRS

At a meeting held at the Waldorf-Astoria Hotel, in New York City, on July 28, the American Uniform Boiler Law Society was formed. Plans were outlined for the raising of at least $12,000 annually to promulgate the adoption of the Standard Boiler Code formulated by the American Society of Mechanical Engineers, and the following members were appointed to serve as members of the administrativ ecouncil: Water-Tube Boilers, Isaac Harter, Jr.; Locomotives, John Wynne; Material Manufacturers and Dealers, D. J. Champion; American Boiler Manufacturers Association, E. R. Fish; Tubular Boilers, T. E. Durban; Threshers and Road Rollers, H. P. Goodling; Hoisting Engines, H. N. Covell; Cast-Iron Heating Boilers, Frederick W. Herendeen; Steam-Shovel Interests, Walter Plehn; Insurance Interests, Charles S. Blake; Low-Pressure Heating Boilers, M. F. Moore; Large Users, no representative as yet.

The council of the American Society of Mechanical Engineers has chosen Spencer Miller and W. L. R. Emmet as the society's representatives on the New Inventions Board that has been established by Secretary Daniels of the Navy Department. Mr. Miller is engineer with the Lidgerwood Co. and has done a great deal of experimental and developmental work on the hoisting apparatus built by that concern. Mr. Emmet is consulting engineer with the General Electric Co. and has specialized on steam turbines.

BUSINESS ITEMS

"Steam Trap Catechism" is the title of a new booklet just issued by the American Steam Gauge & Valve Manufacturing Co., Boston, Mass. It gives important information on steam traps in general and contains many helpful hints on how to buy steam traps. It is sent free on request.

The Coppus Engineering & Equipment Co., Worcester, Mass., has published a new catalog descriptive of the Coppus Turbo Blower for undergrate draft and other industrial purposes. It is well illustrated both with reproductions of photographs of installations and detail drawings and gives a clear description of construction and operation. A note to the company brings a copy.

The machinery, equipment, stock and all personal property of the defunct Wisconsin Engine Co., of Corliss, Wis., has been disposed of to the E. L. Essley Machinery Co., Chicago and Milwaukee. The sale was effected by the receiver, the First Trust Co., of Milwaukee. The price is not given, but it is said to run well into the hundreds of thousands. The deal does not involve the buildings or real estate.

The Essley Co. intends to dismantle the plant at once and use the equipment, which is of the highest type and quality, to fill the great demand for all kinds of machine tools, lathes, engines, etc., in the American metal trades at this time. The engine company's product was Corliss engines, heavy gas engines and pumping engines. The plant has four large brick buildings, a foundry, machine shop, pattern shop, and a warehouse, all erected less than fifteen years ago. Nothing can be learned as to the disposition of the buildings and land, which comprises hundreds of acres.

Engberg's Electric and Mechanical Works, St. Joseph, Mich., has issued a new Bulletin (No. 101) on direct-current generating units from 1 to 50 kw. The bulletin, which is handsomely printed and well illustrated, gives a complete description of the details of the generator and engine, with dimensions and weights of all units. It is a catalog which will be of interest to all who wish to study the construction of direct-current machinery and of moderate size vertical engines, as the detail illustrations are clear and instructive. Copies will be mailed on application.

The Goulds Manufacturing Co., Seneca Falls, N. Y., manufacturer of pumps for every service, has opened a Pittsburgh office in the Henry W. Oliver Building. The new office will be under the management of H. H. Henderson, who has been representing the company in northern West Virginia and southeastern Ohio. E. C. Wayne has been appointed assistant manager. This company has recently made a change in its